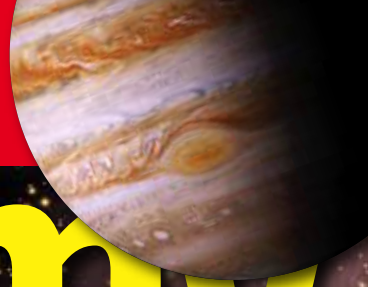
EXCLUSIVE! pull-out star charts

BREAKING NEWS: Pluto-bound New Horizons flies past Jupiter p. 32



April 2007

Astronomy®

The world's best-selling astronomy magazine

Black holes seeing the unseeable

New technology will prove black holes exist p. 26

The Big Bang +1 second p. 38

Explore 12 must-see galaxies p. 54

Black holes cannot be observed directly, but new technology may allow astronomers to view such objects' dark shrouds — event horizons.

AND MORE!

See the sky's most colorful double stars p. 62

An easy guide to astro-speak p. 66

Stephen James O'Meara on sky motions and President Lincoln p. 14

Astronomy.com

$5.95 U.S. • $6.95 CANADA

0 72246 46770 1 04

Vol. 35 • Issue 4

ETX®-80
$299
"The coolest thing we saw in Mexico was Saturn."
Camping out is a great way to see the world.
Just remember that some of nature's grandest
sights are directly over your head.

New **2007 Meade Catalog** is here!

Download or order the 150 page catalog at **meade.com/catalog**

THE ETX®-80 ULTRA-PORTABLE GO TO TELESCOPE

Ever get so far away from the city that the stars look like you could reach out and touch them? Wish you could get just a little closer? Now you can. The ultra-portable ETX-80 is the perfect campground observatory. It's ideal for camping, hiking, picnics, the beach, vacations, or any other time you want to connect with nature and the universe. You can study the craters of the moon, the rings of Saturn, the moons of Jupiter, plus hundreds of galaxies, nebulas, double stars, clusters, you name it. It's also the perfect scope for daytime bird and nature watching too!

MEADE.COM | 800.919.4053

OPTICS PLANET (800.504.5897) • ASTRONOMICS (800.356.6603) • OPT CORP. (800.338.9638)
TELESCOPES.COM (800.958.6030) • WOODLAND HILLS (877.626.3233) • ANACORTES (888.996.3233)
SKIES UNLIMITED (888.947.2673) • CANADA – KHAN SCOPE (800.580.7160)

MEADE®

30-07001

GET THE DEEP SKY IMAGER PRO™
FOR ONLY $129*!
WITH THE PURCHASE OF AN LX90
Regular price – $399
* While supplies last
CCD filters sold separately.
MEADE

24 ORBITING REASONS

the new LX90GPS can locate over 30,000 objects including itself.

Patents: 6,304,376; 6,392,799; 6,563,636; D422,610; and other patents pending. 10-06093.

New **2007 Meade Catalog** is here! Order the 150 page catalog on-line at **meade.com/catalog**

The NEW LX90GPS™ can do more than track satellites. It can communicate with them as well. Turn it on and the built-in Sony® GPS sensor immediately determines your precise date, time and location. Meade's patented Auto-Align™ then uses this info to align your scope for a tour of the most spectacular sights in the universe. With all the features of the legendary LX90 Schmidt-Cassegrain plus the ability to communicate with satellites, the new LX90GPS now has it all. When it comes to industry-leading American-made optics, depth of features, and value for your dollar, the LX90GPS is the best Schmidt-Cassegrain telescope you can find that can find itself.

MEADE

MEADE.COM | 800.919.4053

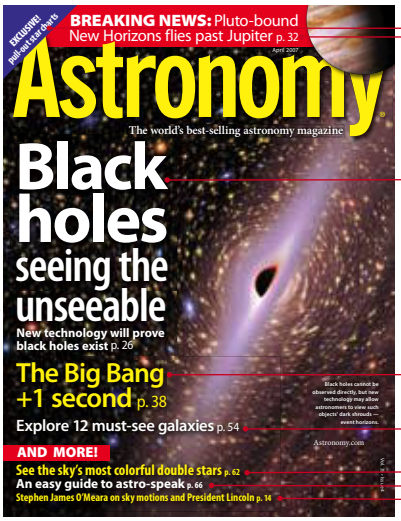
	8"	10"	12"
FOCAL RATIO	F/10	F/10	F/10
PRICE	$1999	$2699	$3299
UHTC™	INCLUDED	INCLUDED	INCLUDED

SHIPPING AND DL NG I CLUDE

- Schmidt-Cassegrain optical design
- Diffraction-limited optics
- Au oAl ™gn
- AutoStar® tel scope controller
- Sony® GPS sensor
- Oversized primary mirror
- SmartDrive™ (Periodic Error Correction)
- 7°/sec Slew/GoTo speed
- Rigid double- in f k mount
- LX200-series sturdy field tripod
- Red-dot finder & 8x50 optical finder
- AutoStar Suite™ AE

30-07002

OPTICS PLANET (800.504.5897) • ASTRONOMICS (800.356.6603) • OPT CORP. (800.338.9638) • TELESCOPES.COM (800.958.6030)
WOODLAND HILLS (877.626.3233) • ANACORTES (888.996.3233) • SKIES UNLIMITED (888.947.2673) • CANADA – KHAN SCOPE (800.580.7160)


EXCLUSIVE! Pull-out star charts
BREAKING NEWS: Pluto-bound New Horizons flies past Jupiter p. 32
April 2007
Astronomy
The world's best-selling astronomy magazine
Black holes seeing the unseeable
New technology will prove black holes exist p. 26
The Big Bang +1 second p. 38
Explore 12 must-see galaxies p. 54
AND MORE!
See the sky's most colorful double stars p. 62
An easy guide to astro-speak p. 66
Stephen James O'Meara on sky motions and President Lincoln p. 14
Black holes cannot be observed directly, but new technology may allow astronomers to view such objects' dark shrouds — event horizons.
Astronomy.com

ADOLF SCHALLER FOR *ASTRONOMY*; INSET: NASA/JPL/SSI

ON THE COVER

44 Pull-out star charts

32 New Horizons flies past Jupiter

26 Black holes: seeing the unseeable

38 The Big Bang + 1 second

54 Explore a dozen must-see galaxies

62 Observe the sky's most colorful double stars

66 An easy guide to astro-speak

14 Poetry in motion

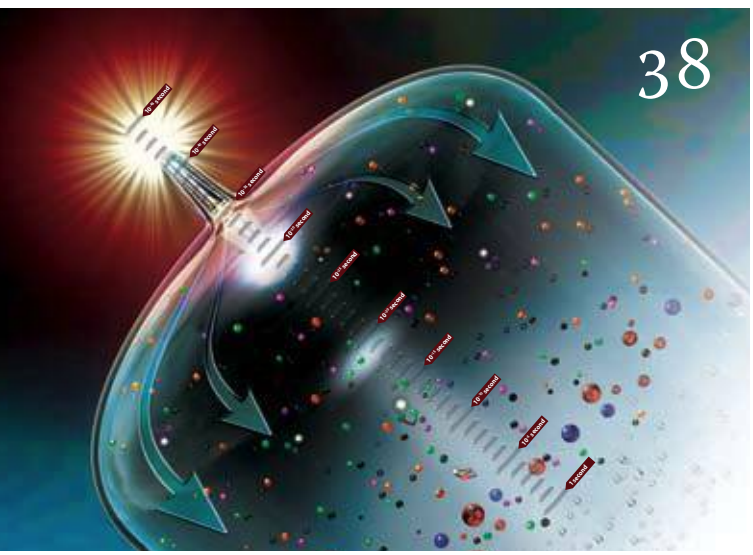
Astronomy

VOL. 35, NO. 4

The world's best-selling astronomy magazine

april 2007

JUPITER: NASA/JPL/SSI; SPACECRAFT: JHUAPL/SwRI



ASTRONOMY: ROEN KELLY

06 **This month in *Astronomy***
New faces at *Astronomy*

08 **Beautiful universe**

10 **Letters**

12 **Bob Berman's strange universe**
If you were in charge

14 **Stephen James O'Meara's secret sky**
Poetry in motion

18 **Astro news**
Stardust turns the table on comet formation; Black hole, big appetite; NASA announces lunar architecture; and more

26 COVER STORY

Black holes: seeing the unseeable
New technology will reveal the event horizon — direct evidence that black holes exist. **STEVE NADIS**
ONLINE EXTRA: See the event horizon in a black-hole simulation.

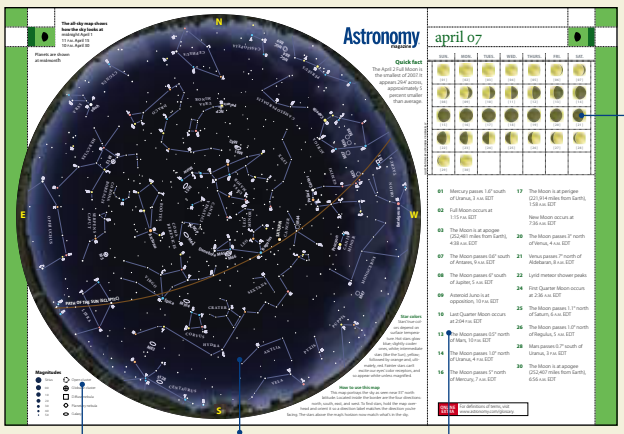
32 **New Horizons flies past Jupiter**
Bound for Pluto, the New Horizons spacecraft gets the closest look at Jupiter and its moons in 4 years. **S. ALAN STERN**
ONLINE EXTRA: Get New Horizons' latest images of Jupiter, and read exclusive updates from S. Alan Stern as the spacecraft nears the planet.

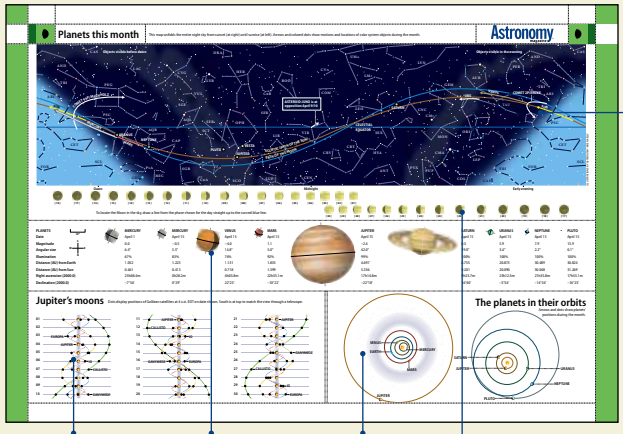
38 **The Big Bang + 1 second**
Scientists are trying to find the torrent of neutrinos unleashed following cosmic genesis. **STEVE NADIS**

44 **The sky this month**
Venus skirts the Pleiades
MARTIN RATCLIFFE AND ALISTER LING

ONLINE EXTRA Get free bonus material at **Astronomy.com/toc**. Follow the instructions on page 10 to gain access.

EXCLUSIVE PULL-OUT STAR CHARTS: Your guides for observing this month's night sky (p. 44)





ILLUSTRATIONS: *ASTRONOMY*: ROEN KELLY

54 **Explore a dozen must-see galaxies**
Venture off the beaten path to observe twelve extragalactic gems Messier missed. **STEVE GOTTLIEB**
ONLINE EXTRA: Check out more springtime galaxies, and download an Autostar tour of all these targets for your Meade go-to telescope.

58 **Ask Astro**
Measuring a magnetar's pulse, why black holes have jets, why you see no green stars, and making sense of constellation boundaries
ONLINE EXTRA: Discuss your questions and answers in our forum.

62 **Observe the sky's most colorful double stars**
You'll have no problem seeing these celestial beauties through a small telescope, even through haze and light pollution. **JAMES MULLANEY**

66 **An easy guide to astro-speak**
If you've ever wondered about some of the terms astronomers use, here's an illustrated guide. **MICHAEL E. BAKICH**

70 **Orion's new 4-inch powerhouse**
The 100ED EQ-G's high-quality optics provide plenty of great sky views at a price that doesn't break the bank. **PHIL HARRINGTON**

74 **Glenn Chaple's observing basics**
Go-to a-go-go

76 **Phil Harrington's binocular universe**
The Lion's roar
ONLINE EXTRA: Get tips on estimating variable stars' brightnesses.

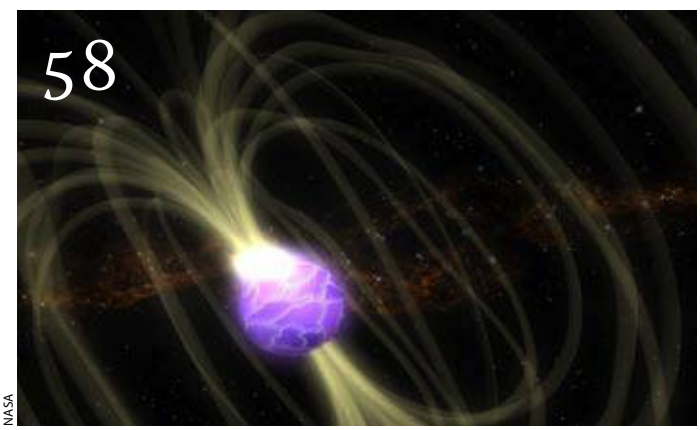
78 **New products**

80 **Coming events**

81 **Advertiser index**

86 **Reader gallery**

ADAM BLOCK/NOAO/AURA/NSF



NASA

ASTRONOMY: THEO COBB; BACKGROUND IMAGE: JOHN CHUMACK

BY DAVID J. EICHER

New faces at *Astronomy*

Last month, I introduced you to our new columnist, Steve O'Meara, and our editorial intern, Katie Neubauer. This month, I have the pleasure of introducing you to two more journalists at *Astronomy*.

Milwaukee resident Daniel Pendick joins our staff as associate editor. He's a new face on our title but not new to Kalmbach Publishing Co. From 1994 through 1996, Dan worked as an associate editor on the now-defunct *Earth* magazine. Aside from being a highly accomplished science writer, Dan brings a lifetime's interest in astronomy and considerable planetarium experience to his new position.

For the past decade, Dan has worked as a freelance writer. His freelance career includes serving as editor for two monthly health-related newsletters published by Belvoir Media Group in Sarasota, Florida. He also attended MIT in 1999 as a Knight Science Journalism Fellow.

Dan has a bachelor's degree in literature and rhetoric from Binghamton University in Binghamton, New York, and a master's in the history of science and medicine from the University of Wisconsin in Madison. Aside from Dan's skill as a writer — you'll note his distinctive voice in many upcoming stories — he enjoys playing blues, country, and bluegrass music on his guitar.

Also, in January, *Astronomy* welcomed a second editorial intern, Erin Dolan. Erin came to us for a monthlong internship from the University of St. Thomas in Saint Paul, Minnesota. She brings enthusiasm and skills in both editorial and art areas to this experience. Erin is a junior majoring in print journalism, visual communications, and Catholic studies. She had the good fortune of studying in Rome last spring and enjoyed traveling throughout Europe. Erin's home is Brookfield, Wisconsin, where she enjoys painting, writing, reading, and watching old movies.

Associate Editor Daniel Pendick
ASTRONOMY: WILLIAM ZUBACK

We've also added some exciting features to our web site, Astronomy.com.

First, in our new "Product showcase" section, *Astronomy*'s staff highlights the latest astronomy-related equipment. Be sure to visit this section before purchasing your next telescope, accessory, or software. Pictures and descriptions will let you in on the best gear. You can find this section at www.astronomy.com/products.

Second, Contributing Editor Phil Harrington has created online articles for city-dwelling observers. In his "Urban skies" series, Phil shows you how to observe from any location, the appropriate equipment, and best light-pollution targets. You'll find his advice at www.astronomy.com/urbanskies.

Lastly, if you haven't had a chance, be sure to check out our weekly podcast. The shows' topics range from discussions with scientists about their cutting-edge research and life in the universe to constellation tours. For our complete episode archive, visit www.astronomy.com/podcast.

Yours truly,

David J. Eicher
Editor

Astronomy

Volume 35, Number 4

Editor David J. Eicher
Art Director LuAnn Williams Belter

EDITORIAL STAFF
Managing Editor Dick McNally
Senior Editors Michael E. Bakich, Richard Talcott
Associate Editors Laura Baird, Laura Layton, Daniel Pendick, Francis Reddy
Assistant Editor Jeremy McGovern
Editorial Assistant Valerie Penton
Editorial Intern Katie Neubauer

ART STAFF
Graphic Designer Joel Marsh
Illustrators Theo Cobb, Rick Johnson, Roen Kelly
Production Coordinator Joni Hauser

CONTRIBUTING EDITORS
Bob Berman, Glenn F. Chaple, Jr., Stephen J. Edberg, Phil Harrington, David Healy, Ray Jayawardhana, Alister Ling, Steve Nadis, Stephen James O'Meara, Tom Polakis, Martin Ratcliffe, Mike D. Reynolds, William Schomaker, John Shibley, Raymond Shubinski

EDITORIAL ADVISORY BOARD
Buzz Aldrin, Marcia Bartusiak, Timothy Ferris, Alex Filippenko, Adam Frank, John S. Gallagher III, William K. Hartmann, Paul Hodge, Anne L. Kinney, Edward Kolb, Stephen P. Maran, S. Alan Stern, James Trefil

[Kalmbach Publishing Co.]
President Gerald B. Boettcher
Vice President, Editorial, Publisher Kevin P. Keefe
Vice President, Advertising Scott Stollberg
Corporate Art Director Maureen M. Schimmel
Managing Art Director Michael Soliday
Production Manager Annette Wall
Corporate Circulation Director Michael Barbee
Single Copy Sales Director Jerry Burstein
Circulation Specialist Nicole Radomski
Circulation Coordinator Natalie Kranzman

ADVERTISING DEPARTMENT
(888) 558-1544
Advertising Sales Manager Howard Hoerl
hhoerl@astronomy.com
Advertising Sales Representative Ken Kozerski
kkozerski@astronomy.com
Ad Services Representative Katie Wendt
kwendt@kalmbach.com

RETAIL TRADE ORDERS AND INQUIRIES
(800) 558-1544, ext. 818; outside the U.S. and Canada: (262) 796-8776, ext. 818

CUSTOMER SALES AND SERVICE
(800) 533-6644; fax: (262) 796-1615
customerservice@kalmbach.com

SPECIAL E-MAIL ADDRESSES
Ad Sales adsales@astronomy.com
Ask Astro askastro@astronomy.com
Books books@astronomy.com
Letters letters@astronomy.com
Products products@astronomy.com
Reader gallery readergallery@astronomy.com

The Audit Bureau

Editorial phone: (262) 796-8776; advertising: (888) 558-1544; customer service & sales: (800) 533-6644; outside the U.S. and Canada: (262) 796-8776, ext. 421, Monday through Friday, 8:30 A.M. to 5 P.M. CT, Fax: (262) 796-1615; E-mail: customerservice@kalmbach.com. Please include your name, mailing address, and telephone number with any correspondence.

Copyright © 2007 Kalmbach Publishing Co., all rights reserved. Material in this publication may not be reproduced in any form without permission.
Printed in the U.S.A. Allow 6 to 8 weeks for new subscriptions and address changes. Subscription rate: single copy: $5.95; 1 year $42.95, 2 years (24 issues) $79.95, 3 years (36 issues) $114.95; Canadian & foreign: 1 year $58, 2 years $110, 3 years $160. Payable in U.S. funds drawn on U.S. Banks. (Canadian price includes GST.) Expedited Delivery Service Surcharges: Domestic 1st Class $30 per year, Canadian air $30 per year, Foreign air, $60 per year. BN 12271 3209 RT. Not responsible for unsolicited materials.

MEADE®

PREMIUM ACCESSORIES

www.meade.com/accessories or call 800-919-4053

Ultra Wide Angle Series 5000™

82° AFOV

Focal Length	Barrel Size	AFOV	Price
4.7	1.25"	82°	$199
6.7	1.25"	82°	$199
8.8	1.25"	82°	$199
14	1.25"	82°	$199
18	1.25"	82°	$279
24	2.00"	82°	$399
30	2.00"	82°	$449

Ultra Wide Angle Set $749
Includes: 6.7, 18, 30mm and aluminum case

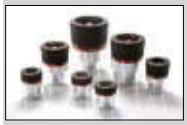
Super Wide Angle Series 5000™

68° AFOV

Focal Length	Barrel Size	AFOV	Price
16	1.25"	68°	$179
20	1.25"	68°	$199
24	1.25"	68°	$249
28	2.00"	68°	$279
34	2.00"	68°	$299
40	2.00"	68°	$399

Super Wide Angle Set $599
Includes: 16, 24, 34mm and aluminum case

5 Element Plössl Series 5000™



60° AFOV

Focal Length	Barrel Size	AFOV	Price
5.5	1.25"	60°	$89
9	1.25"	60°	$89
14	1.25"	60°	$89
20	1.25"	60°	$89
26	1.25"	60°	$99
32	2.00"	60°	$149
40	2.00"	60°	$199

5 Element Plössl Set $349
Includes: 5.5, 14, 20, 32mm and aluminum case

TeleXtenders Series 5000™

Magnification	Barrel Size	Price
2x	1.25"	$159
3x	1.25"	$159
5x	1.25"	$159
2x	2.00"	$229

2" Enhanced Diagonal Series 5000™

NEW

- Enhanced dielectric coatings with 99% reflectivity over the visual spectrum
- Interferometer tested
- Thermally stable Pyrex® glass
- Includes 1.25" eyepiece adapter with non-marring compression ring

$199.00

QX Wide Angle Eyepieces Series 4000™

70° AFOV

Focal Length	Barrel Size	AFOV	Price
15mm	1.25"	70°	$79
20mm	1.25"	70°	$79
26mm	2.0"	70°	$89
30mm	2.0"	70°	$89
36mm	2.0"	70°	$99

Eyepiece & Filter Set Series 4000™

NEW

Designed and manufactured to exacting standards. Series 4000 Super Plössl eyepieces deliver 52˚AFOV (44˚ for the SP40mm) with all of the resolution, edge-of-field sharpness and color correction demanded in the most advanced visual applications.

$299

Only **$199** if purchased together with any Meade telescope.

Each Series 4000 Set Includes:

6.4mm Super Plössl	$49
9.7mm Super Plössl	$49
12.4mm Super Plössl	$49
15mm Super Plössl	$49
32mm Super Plössl	$69
40mm Super Plössl	$69
2x Barlow Lens (#126)	$48
Color Filter Set #1 (yellow/red/green/blue)	$49
Moon Filter	$17
Aluminum Hard Carry Case	$69
Total price if purchased separately	**$517**

Deep Sky Imager™ with AutoStar Suite™

DSI

DSI Pro

DSI (Color)	$299
DSI Pro (Monochrome)	$399
DSI Pro with filters	$499
DSI II (Color)	$599
DSI II Pro (Monochrome)	$599
DSI II Pro with filters	$699

more info at meade.com/dsi

Lunar Planetary Imager (LPI™)

Now $99

The LPI™ camera will have you taking pictures of the moon and planets like a pro – right out of the box with exclusive features like Meade's Drizzle Technology™.

more info at meade.com/lpi

AC Adapters

- **RCX400™ AC Adapter** For RCX400, LX200™GPS, LX200R™, LX90™, LX90GPS™, LXD55, LXD75 telescopes — **$79**
- **#541 AC adapter** For LX90GPS, LX90, LX10, EXT˚90, EXT105, EXT125 telescopes — **$49**
- **#546 AC adapter** For EXT˚60, EXT70, EXT80, DS-2000, NG series telescopes — **$19**
- **#607 cigarette lighter adapter** For all Meade telescopes — **$25**

Focal Reducers Series 4000™

$129

f/6.3 Focal Reducer *
- 4-element, multi-coated
- Reduces exposure times by approximately 50%

$149

f/3.3 CCD Focal Reducer *
- 3-element, multi-coated
- Variable T-adapter included

* For photographic use only

Wireless AutoStar® II

Now $199

Remote control of your telescope has never offered such freedom. Just plug the Wireless AutoStar II into the handbox port of your LX200GPS, LX200R, or RCX400 telescope and wireless control of the universe is at your fingertips.

* Only for use on LX200GPS, LX200R and RCX400 telescopes.

MEADE AUTHORIZED DEALERS

OPTICS PLANET
800-504-5897

ASTRONOMICS
800-356-6603

OPT CORP.
800-338-9638

TELESCOPES.COM
800-958-6030

WOODLAND HILLS
877-626-3233

ANACORTES
888-996-3233

SKIES UNLIMITED
888.947.2673

CANADA
KHAN SCOPE
800-580-7160

Ultra-Wedge

- Heavy-duty construction
- Ultra-smooth, fine tune adjustments
- High-precision polar alignment
- Rock solid

$499

* For LX90, LX200, and RCX400 series telescopes.

Copyright © 2007 Meade Instruments Corporation. Patents Pending. All rights reserved. 30-07003.

In-your-face galaxy

Brilliant blue star clusters and rosy clouds of glowing hydrogen pepper the face-on spiral galaxy NGC 2403 in Camelopardalis. This 8th-magnitude galaxy lies on the outskirts of the M81 group, about 11 million light-years from Earth, making it one of the nearest spirals beyond the Local Group. Astronomers classify NGC 2403 as an Sc-type galaxy — one with a small nucleus and loosely wound spiral arms. American astronomer Edwin Hubble (1889–1953) discovered Cepheid variables — stars that vary with periods related to their intrinsic brightnesses — in NGC 2403. That was the first time such stars were found outside the Local Group. They helped Hubble show the universe is expanding. SUBARU TELESCOPE/NAOJ

Big Bang vs. inflation

In "Top 10 astronomy stories of 2006" (January 2007), Francis Reddy writes in the number 2 story, "WMAP glimpses cosmic inflation," that during inflation, "the universe went through a hyper-fast expansion a fraction of a second after the Big Bang." In *Many Worlds in One: The search for other universes* (Hill and Wang, 2006), author Alex Vilenkin states the Big Bang marks the end of inflation. It is the moment and location where the eternally inflating sea of false (high-energy) vacuum decays into a true (low-energy) vacuum, releasing a fireball of elementary particles and radiation that creates a new island universe.

The fireball expands, resulting in the continual expansion of our universe or region of space-time, but this expansion should not be confused with inflation. The fact that the expansion of our universe is accelerating is similar to inflation in that it is apparently driven by residual or dark energy in the true vacuum. **— RICK NAGIN,** CLEVELAND

THE CRAB NEBULA became visible in 1054, but the pulsar at its center wasn't discovered until 1968. NASA/ESA/ J. HESTER AND A. LOLL (ASU)

Some cosmologists argue inflation occurred before the Big Bang, and others say inflation followed it. WMAP's lead researcher, Charles Bennett, agrees with Vilenkin on the timing, but he recognizes many cosmologists don't share this view.

Compared to the WMAP team's success in proving the fact of inflation, this disagreement is a fine point. As they say here in the Midwest, "Six of one, a half dozen of the other." **— FRANCIS REDDY,** ASSOCIATE EDITOR

Another "Windy city"

One of your online polls asked: How cold does it have to be for you to skip observing?

The responses to choose from didn't address windy conditions. At an elevation of 7,000 feet (2.1 kilometers) in Arizona, we get days with 60 mph (97 km/h) sustained winds and gusts to 90 mph (145 km/h).

If the temperature is below freezing but there's little or no wind, that's relatively good for viewing. So, while it may be cold, if it is not cloudy, windy, or snowing, I'll be outside observing. **— VIRGIL COOPER,** VERNON, ARIZONA

What do you think? Visit Astronomy.com to vote in our weekly poll. Or check out the posts on astronomy.com/blogs to read the latest news and opinions from the Astronomy *staff.*

It's in the mail

When *Astronomy* hits my mailbox, I feel like a kid with a new comic book. I toss the bills and junk mail and go directly to "Bob Berman's strange universe." He never fails to make me chuckle. Nice work, Bob! **— GEORGE DREITLEIN,** LITTLE FALLS, NEW JERSEY

Corrections

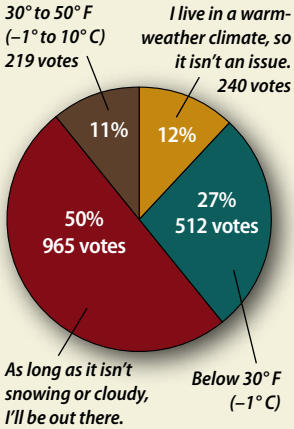
In "Sun studio" (January 2007), the Sun's diameter was given incorrectly. The Sun spans 110 Earth-widths.

"All about the Crab Nebula" (January 2007) incorrectly stated Jocelyn Bell discovered the pulsar in the Crab Nebula in 1967. The Crab pulsar was discovered in 1968 by David H. Staelin and Edward C. Reifenstein III with the Arecibo 300-meter radio telescope in Puerto Rico. **— *ASTRONOMY* EDITORS**

We welcome your comments. Send letters to Astronomy *Letters, P. O. Box 1612, Waukesha, WI 53187; e-mail to letters@astronomy.com. Please include your name, city, state, and country. Letters may be edited for space and clarity.*

Online poll results

POLL QUESTION:
How cold does it have to be for you to skip observing?


30° to 50° F (–1° to 10° C) 219 votes
I live in a warm-weather climate, so it isn't an issue. 240 votes
11%
12%
27% 512 votes
50% 965 votes
As long as it isn't snowing or cloudy, I'll be out there.
Below 30° F (–1° C)

Total votes: 1,936

Join the fun! Each week, Astronomy.com posts a poll question for visitors to answer. You can find the question on the lower right side of the home page.

Get more from Astronomy.com

Astronomy magazine readers have access to free, premium online content at Astronomy.com.

You must have an Astronomy.com account to view this content.

To create an account, go to www.astronomy.com/register.

Subscribers: Click "Create Magazine Subscriber Account" and enter the customer number on your subscription label. You'll enjoy unlimited access to the web site for the life of your subscription.

Newsstand buyers: Click "Create Newsstand Buyer Account" and enter this month's access code:

UP7H4A

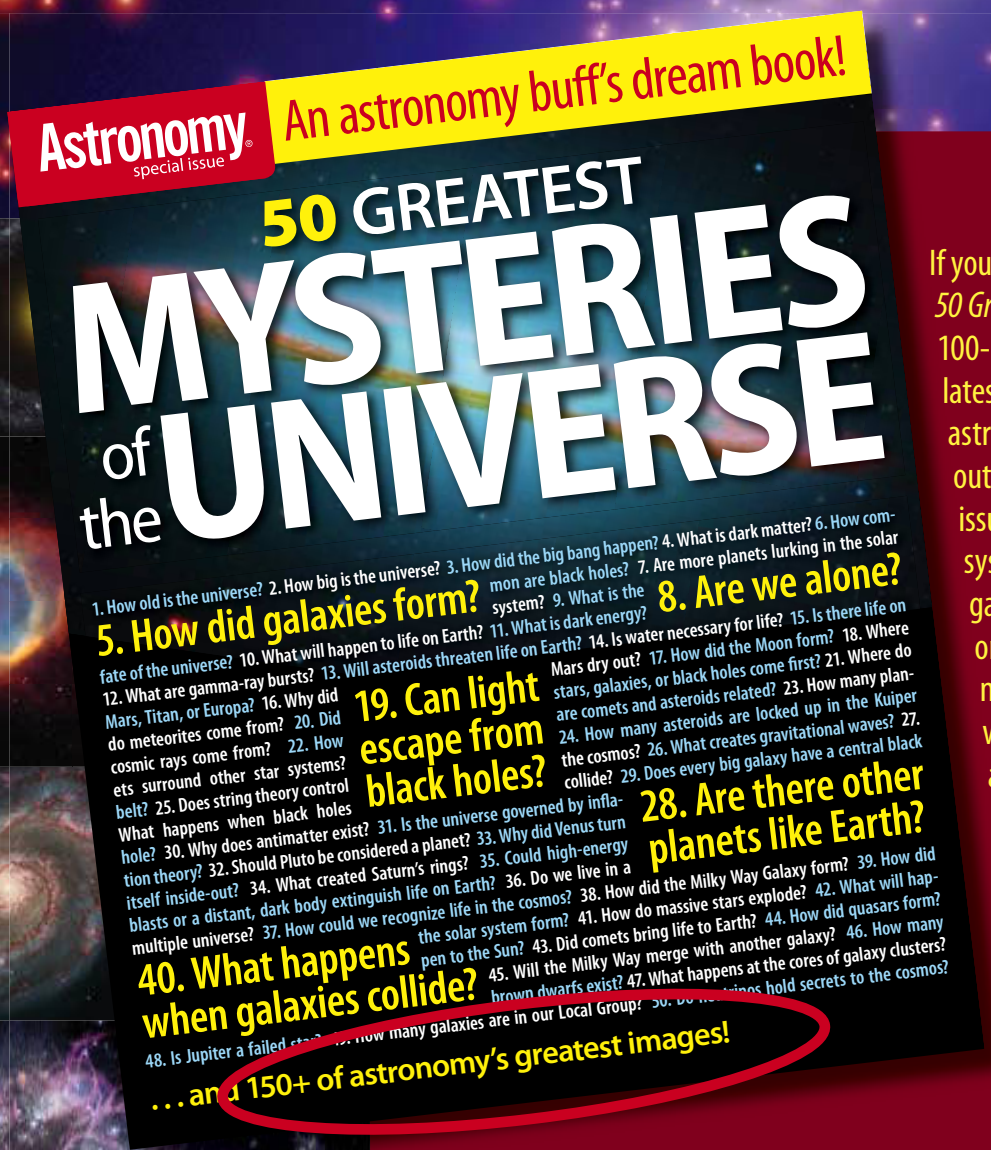
If you've previously registered as a newsstand buyer, log in, click "My Account," and enter the code above.

You'll enjoy unlimited web-site access through the last day of the month listed on the cover.

ONLINE CONTENT

Astronomy.com has a **new "Product showcase"** that gives you the scoop on all the latest accessories and equipment. Check it out at **astronomy.com/products.**

Amaze your friends at the next party!


Astronomy special issue
An astronomy buff's dream book!
50 GREATEST
MYSTERIES of the UNIVERSE
1. How old is the universe? 2. How big is the universe? 3. How did the big bang happen? 4. What is dark matter? 6. How com-
5. How did galaxies form?
mon are black holes? 7. Are more planets lurking in the solar
fate of the universe? 10. What will happen to life on Earth? 11. What is dark energy?
system? 9. What is the
8. Are we alone?
12. What are gamma-ray bursts? 13. Will asteroids threaten life on Earth? 14. Is water necessary for life? 15. Is there life on
Mars, Titan, or Europa? 16. Why did
19. Can light escape from black holes?
Mars dry out? 17. How did the Moon form? 18. Where
do meteorites come from? 20. Did
stars, galaxies, or black holes come first? 21. Where do
cosmic rays come from? 22. How
are comets and asteroids related? 23. How many plan-
ets surround other star systems?
24. How many asteroids are locked up in the Kuiper
belt? 25. Does string theory control
the cosmos? 26. What creates gravitational waves? 27.
What happens when black holes
collide? 29. Does every big galaxy have a central black
hole? 30. Why does antimatter exist? 31. Is the universe governed by infla-
28. Are there other planets like Earth?
tion theory? 32. Should Pluto be considered a planet? 33. Why did Venus turn
itself inside-out? 34. What created Saturn's rings? 35. Could high-energy
blasts or a distant, dark body extinguish life on Earth? 36. Do we live in a
multiple universe? 37. How could we recognize life in the cosmos? 38. How did the Milky Way Galaxy form? 39. How did
the solar system form? 41. How do massive stars explode? 42. What will hap-
40. What happens when galaxies collide?
pen to the Sun? 43. Did comets bring life to Earth? 44. How did quasars form?
45. Will the Milky Way merge with another galaxy? 46. How many
brown dwarfs exist? 47. What happens at the cores of galaxy clusters?
48. Is Jupiter a failed star? 49. How many galaxies are in our Local Group? 50. Do neutrinos hold secrets to the cosmos?
. . . and 150+ of astronomy's greatest images!

Reserve your copy TODAY!

If you like astronomy, you'll love *50 Greatest Mysteries of the Universe*. This 100-page special issue is packed with the latest scientific knowledge about all of astronomy's big questions. You'll find out cutting-edge answers to the biggest issues in cosmology, wonders of the solar system, how the Milky Way and other galaxies work, and the latest insider news on stars and planets. It's everything you need to be an expert on the universe, written in easy-to-understand language and beautifully illustrated with dozens of images and clear illustrations. This collector's edition is one you'll spend hours with and will share with your friends and family!

Don't miss this issue!

Act now and SAVE $1 off the newsstand price!

Simply fill out and mail the attached card!

Or call 1-800-533-6644

(Mon-Fri, 8:30am-5:00pm CST. Outside the U.S. and Canada, call 262-796-8776 x661.)

Order online at Astronomy.com

U.S. price $8.95. Canadian price $10.50 (GST included, payable in U.S. funds). Foreign price $10.50 (payable in U.S. funds, checks must be drawn on a U.S. bank). Make checks payable to Kalmbach Publishing Co.

Astronomy's Collector's Edition *50 Greatest Mysteries of the Universe* will arrive in May 2007.

CIR-ADH-06X1397RH

Astronomy® magazine

A74AA4

BY BOB BERMAN

If you were in charge

Humans naturally wonder: What do we do next? And by "we" I don't mean the "we" who watch TV lying down because it's too much trouble to sit up. I mean the "we" who discovered penicillin, built the pyramids, and invented trash bag twist-ties. The brilliant "we." The "we" who

launched GPS, rather than the "we" who cranked the Titanic's engines to full speed in seawater the temperature of a Slurpee.

Are you "we?" Absolutely. Aren't you full of ideas how to spend astronomy dollars if Congress bewilderingly put you in charge? First, naturally, you'd appoint your friends as advisors, and then teleconference with them on a new 1080p high-definition screen installed in your office overlooking the space shuttle's launch pad.

Sending in your coolest mega-project is probably the same one that makes every astro-nerd drool. You know you want a new super-sized space telescope, with cheese. Except, cross that off the wish-menu, it's already a done deal. The James Webb Space Telescope will launch in 2013.

This colossus, while we're thinking grandly, ought to be joined by a new mega-giant Earth-based telescope. Give it a mirror large enough to put your house and a swimming pool on. Well, hmm, that's pretty much in the works with the European Extremely Large Telescope in Chile.

Message to mom for your next birthday: You also want access to an observatory, live, in real time, from your home computer, where you can choose where the scope points, and the full-color images flood your screen. Bingo, done. SLOOH already offers that service. They operate an automated observatory in the Canary Islands. You can control it at your desk in your underwear. (Full disclosure: I do web casts for SLOOH, but not always in my underwear.)

From local astronomy to off-planet, then. Let's orbit Jupiter and take high-res pictures. Oops, already did that. Okay, Saturn then. Shazaam, Cassini is there, still doing its thing. How about visiting Pluto? Already en route. Mars? No need to ask. Missions launch every 2 years.

Earth: Let's investigate things that head our way or endanger us. We could send out a pair of spacecraft to watch the Sun in 3-D, like giant binoculars, so we can duck as we see coronal mass ejections coming straight at us like in an IMAX 3-D movie. Very cool, but already built. How about spacecraft that map the cosmic microwave background, measure star distances, see the cosmos in hidden wavelengths, visit comets? Check, check, check, and check.

> SENDING IN YOUR coolest mega-project is probably the same one that makes every astro-nerd drool.

Have we done it all? Can we stop spending all those taxpayer play-dollars?

A member of the "we" crowd would say, "No way!" We've still got to send robots to Europa to drill through that moon's floating ice and see what may be swimming in its oceans. Europa is what we astro-geeks want more than anything else right now. Betcha we even find life there. NASA, JPL, Caltech, Carnegie, and the other space groups keep doing the things we ourselves would do. The right things. "We," the big "WE," we've got it together. We're cool. So, now, during this month, let's switch gears and see what happens when logic doesn't prevail.

Happy scientists at Russia's Pavlov Institute have been practically drooling with excitement over their outer-space animal-rights project. At a recent press conference, the researchers illustrated their progress since 1957, when their country orbited a dog. That single event sparked the pro-mammal riots in South America.

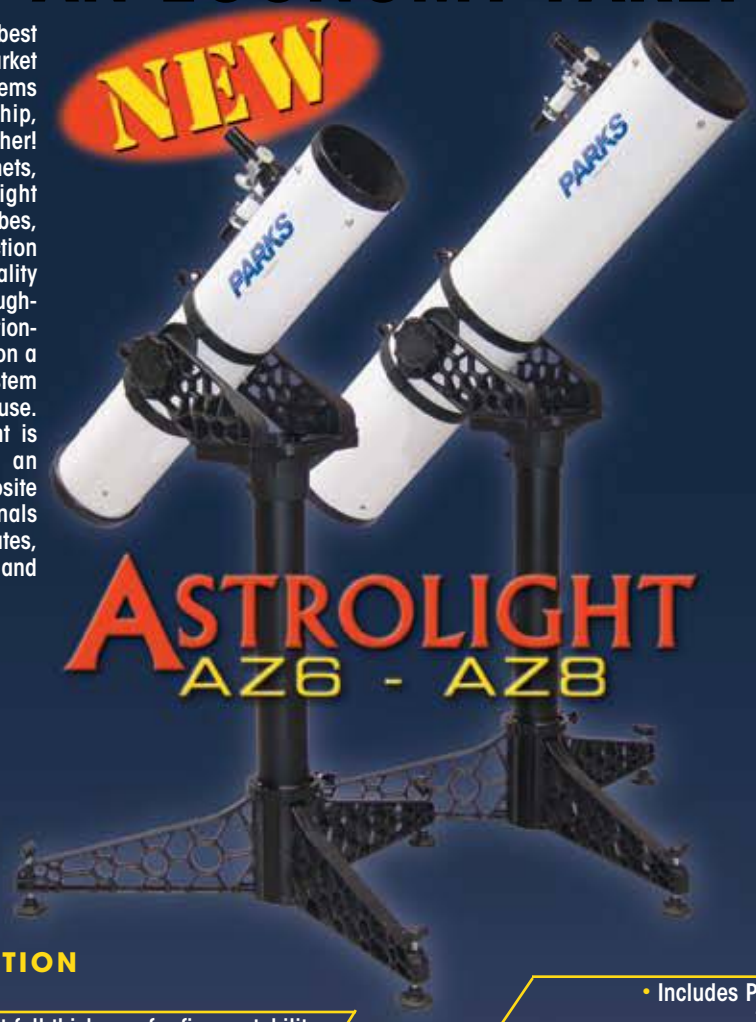
April will see a test of the new rules, when Japan launches an experimental spacecraft containing two dozen scallops and a schnauzer. The primary biology research is aimed at studying the animals' reaction to being vaporized, a necessary first step in assessing the practicality of human landings on stars.

"Fools' efforts to disprove the lack of false negatives have failed," says project spokesperson Nona Neinyet, in an interview published in the research journal *Rat Week*. Others disagreed. In particular, Wildlife International spokesanimal Lisa LaChat urged space funding for reptiles and other under-represented species. Ms. LaChat, speaking for "the entire carbon-based community," also demanded that Congress declare April "Virus Month."

Day. Night. The Earth keeps turning as the controversial launch date approaches. According to a study by the World Organization Of Furriers (WOOF), sending schnauzers into the Sun "is probably harmless." WOOF also called the plaque attached to the new spacecraft "critically important." But others wondered whether aliens could decipher the plaque's message, because it requires linking the first word of each paragraph. The first word of each paragraph! On this very page! That's the only way to learn the secret space message.

TRAVEL THE UNIVERSE FIRST CLASS... AT AN ECONOMY FARE!

Designed and engineered to be the very best performing Newtonian reflectors on the market today, the NEW Parks Astrolight AZ Systems provide superior imaging, craftsmanship, construction and viewing comfort like no other! Delivering superb images of the moon, planets, nebulae and deep sky objects, Astrolight Systems utilize Parks genuine Fiberglass Tubes, Parks LEGENDARY fine annealed diffraction limited Pyrex mirrors and the highest quality mechanical and optical components throughout! Available in 6" and 8" sizes, the revolutionary Parks Astrolight Systems are mounted on a very smooth operating alt-azimuth pier system developed for comfort, stability, and ease of use. The NEW light weight Astrolight AZ Mount is a ground-breaking design made from an advanced glass filled, high impact composite ABS material. Beginners and professionals alike will love its features! Sets up in minutes, transports with ease, operates effortlessly, and lasts a life time – GUARANTEED!



INTRODUCTORY PRICE
Astrolight AZ6 $799
Astrolight AZ8 $999

PARKS precision handcrafted optics produce exceptional images!

Utilizes an advanced composite material; extremely tough, yet light weight!

Transporting your Astrolight is a Breeze!

SPECIFICATIONS

OPTICAL TUBE	AZ6	AZ8
Mirror Diameter	6"/152mm	8"/203mm
F Ratio	f/6	f/6
Focal Length	910mm	1,220mm
Weight	12 lb.	21 lb.
Tube Length	39"	51"

ASTROLIGHT AZ MOUNT	
Height	45"
Weight	25 lb.
Footprint	21" Radius
Pier Finish	Black Powder Coat
Altitude Range	Horizon to Zenith
Azimuth Range	360 Degrees
Eyepiece Tray	Holds 4 1.25" Eyepieces

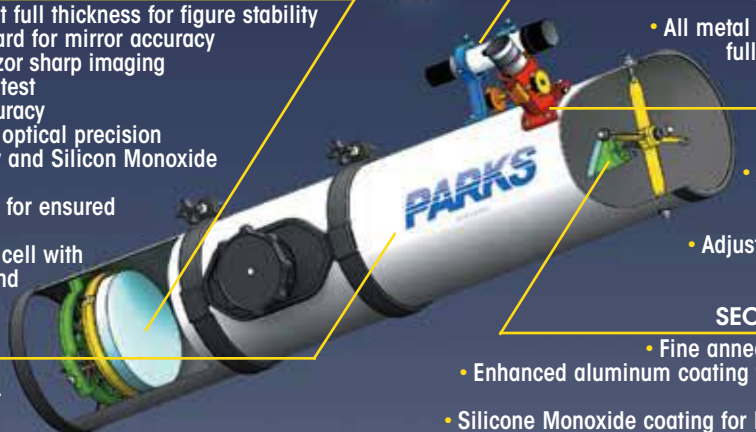
OPTICAL TUBE CONSTRUCTION

PRIMARY MIRROR SYSTEM:

- Made from fine annealed Pyrex mirrors at full thickness for figure stability
- Guaranteed to exceed the industry standard for mirror accuracy
- Guaranteed to be diffraction limited for razor sharp imaging
- Passes the double pass auto-collimation test
- Passes the Foucault test for parabolic accuracy
- Will meet or surpass the Raleigh limit of optical precision
- Aluminized for maximum light reflectivity and Silicon Monoxide overcoated for long lasting performance
- Individually figured, tested and serialized for ensured quality and authenticity
- Secured in genuine Parks primary mirror cell with advanced airflow, thermal equalization and "lock in position" collimation features

GENUINE FIBERGLASS TUBES:

- Rigid and lightweight construction
- Color impregnated gloss white finish that will never peel
- Low thermal conductivity / No thermal expansion
- Flat black, rough textured interior for light absorption and sharper imaging
- Includes protective black End Rings with durable Dust Caps



FINDERSCOPE:

- Includes Parks high quality 6x30 crosshair finderscope with 7° field of view
- All metal construction for finderscope and fully adjustable finderscope bracket

FOCUSER:

- Includes high quality 1.25" Rack & Pinion focuser
- All metal heavy duty construction
- Precise fit for smooth travel and accurate focusing
- Adjustable tension for proper focusing in all applications

SECONDARY MIRROR SYSTEM:

- Fine annealed, full thickness Pyrex mirrors
- Enhanced aluminum coating for increased light transmittance and brighter images
- Silicone Monoxide coating for lasting protection and longer life
- Secured in fully adjustable flat black aircraft aluminum mirror holders
- Held in place by Parks flat black spider vanes for minimum light loss and maximum stability

PARKS

To order the NEW Astrolight AZ Systems and to see the full line of genuine Parks products, visit **www.parksoptical.com**

PARKS OPTICAL, INC
750 Easy Street, Simi Valley, CA 93065 USA
805.522.6722 • Fax 805.522.0033

AMERICAN MADE

Prices do not include shipping and handling or state taxes where applicable.

BY STEPHEN JAMES O'MEARA

Poetry in motion

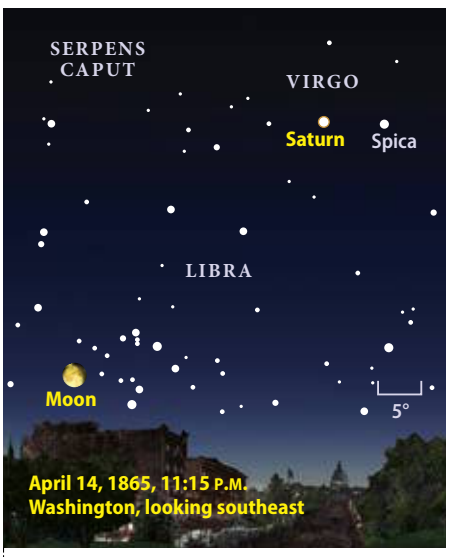
When Lilacs Last in the Dooryard Bloom'd, written in 1865, is Walt Whitman's greatest elegy on the death of President Abraham Lincoln. In it, Venus symbolizes the assassinated president. The planet's nightly march toward the western horizon represents the Great

Emancipator's last days on Earth. And the planet's passage beneath the western horizon mirrors Lincoln's death, the poet's grief, and the ultimate fate of all.

The poem is divided into 16 sections — Lincoln was the United States' 16th president — and these lines from its eighth section recently grabbed my attention:

"As you droop'd from the sky low down as if to my side, (while the other stars all look'd on,) / … As my soul in its trouble dissatisfied sank, as where you sad orb, / Concluded, dropt in the night, and was gone."

Whitman began to compose this poem almost immediately after hearing of Lincoln's assassination. At the time, Venus was high in the west after sunset, before vanishing below the horizon May 4, 1865 — the day of Lincoln's interment.



THE MOON JOINED SATURN in the sky above Washington as news of Lincoln's assassination spread through the nation's capital. *ASTRONOMY:* ROEN KELLY

For me, what's striking about these lines is not their rich symbolism, but their power in transforming the two-dimensional sky into three dimensions: Seeing Earth's horizon occult Venus pushes our sister planet beyond the blue, and seeing Venus move against the sky thrusts the stars beyond the planet.

Simple observations like these were the foundations of ancient astronomical knowledge. They also led to one of the most famous illusions in astronomical history: the Earth-centered universe — an erroneous scheme of the heavens that placed Mercury closer to Earth than Venus, and the Sun between the orbits of Venus and Mars.

It's easy to understand why: Motion is one of the principal clues used by our visual sense to fathom distance. If we drive past a fence, it will appear to move faster than the house behind the fence, which will appear to move faster than a hill behind the house, and so on. Experience tells our brains that closer objects move faster. Yet despite our advanced knowledge of the scale and order of things in the sky today, our minds are still naive when it comes to depth perception. Consider when the Moon and planets pass near one another as observed through binoculars.

Binocular illusions

On December 10, 2006, my friend Amos Meyers and I watched Jupiter, Mercury, and Mars huddle low in the east-southeast at dawn from Volcano, Hawaii. My 10x50 binoculars provided an amazing view of this conjunction. Jupiter and Mercury were only about 1° apart, with Mars another ½° farther away. What struck us, however, was the illusion that Jupiter appeared closer to us than Mercury — a reminder that perception is not reality.

THE CONJUNCTION of December 10, 2006, brought three planets into this view with Scorpius' Graffias. RICHARD HARDMAN

As with motion, when we look at objects beyond the limits of stereoscopic vision (about 1,500 to 2,000 feet [457 to 610 meters]), our eye-brain system relies on experience to judge distance. Typically, objects close to the eye will appear larger and brighter than objects farther away; closer objects also will show more detail than more distant ones. Because Jupiter was about a magnitude brighter than Mercury, it looked closer. With little effort, I could override that visual impression and mentally force Jupiter

to appear farther away. The visual solution, then, can change with new information.

But our 3-D journey was not over. That morning, Saturn was high overhead, about 1° south of a waning gibbous Moon. Again, through binoculars, Saturn looked unmistakably closer than our satellite. This observation flies in the face of reason. The Moon not only is much larger and brighter than the ringed planet, but it also shows greater detail. Based on visual experience, the Moon should have looked like it was closer in the mind's eye. And although I could visually push Saturn behind the Moon, it required a Herculean mental effort. Why?

The dominant eye

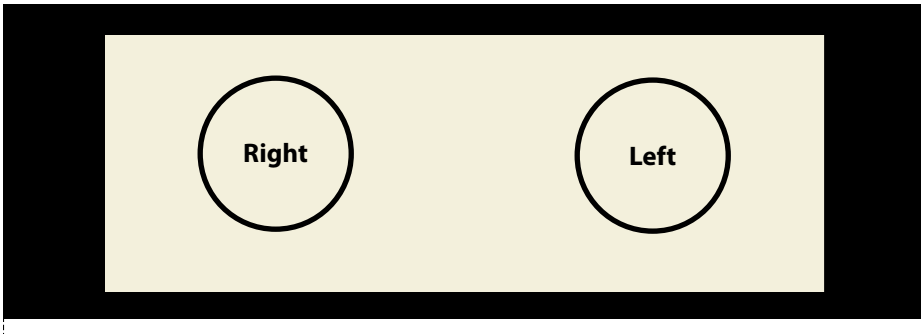
Once home, something dawned on me. In both observations, the object that appeared closest was to the right in the visual field. From our viewing perspective, Saturn was to the right of the Moon, and Jupiter was to the right of Mercury. Perhaps, when we use binoculars to look at two close celestial objects, the dominant eye determines which object appears closest. My dominant eye is my right one. (To find your dominant eye, select an object 20 feet [6 meters] away, close one eye, and point to it; the open eye is dominant.)

To test this theory, I went out December 12 and looked at Jupiter and Mercury again through binoculars. At first, Jupiter appeared closer than Mercury. But when I twisted my body so that the solar system's innermost planet appeared to the right of Jupiter, Mercury looked closer.

Did I bias myself? I think not. But who knows the power of the mind?

TRY OBSERVING SATURN and the Moon's descent through the western sky April 24 before the duo sets in the early hours of April 25. *ASTRONOMY:* ROEN KELLY

There's still much to be learned about depth perception. For instance, my observing partner from December 10, Amos Meyers, has cross-dominant eyes, with a left-eye bias. Why did he, then, see the same illusions as I? The fact is no two people perceive the same reality. What we see depends largely on how the brain selects information from our complex history of personal experience. But you can help investigate the matter by examining a celestial pairing in the April sky.



USE THIS STEREOGRAM to determine which eye is dominant. Looking at this diagram, cross your eyes slightly until three circles appear. The word you read in the center circle indicates your dominant eye. *ASTRONOMY:* ROEN KELLY

On the night of April 24/25, the waxing gibbous Moon will skim past Saturn for observers living in the continental United States. If it's clear, watch their close approach through 10x50 binoculars. Can you perceive the illusion of depth? Does your dominant eye play a role in what you see? Does depth perception vary with angular separation? Meyers wonders what would happen if you turn your body so that Saturn appears above or below the Moon. Be sure to send detailed reports to me at someara@interpac.net.

By the way, when John Wilkes Booth shot President Lincoln in Ford's Theatre April 14, 1865, a waning gibbous Moon was rising about 40° east of Saturn. The Moon had sailed within 5° of the ringed planet only 3 days before. If you go outside after sunset any day during this month, you'll see Venus burning prominently in the west, just as it did 142 years ago when Whitman watched it with solemn eyes. This month, though, Venus still marches to the east — a fitting symbol for the spiritual rise of Lincoln after his death.

Tele Vue® Eyepieces in Your Scope Make Star Charts Come Alive!

Nagler™ 82°
2.5mm to 31mm
"Tops in the field"

Panoptic™ 68°
15mm to 41mm
"Tack Sharp" favorite

Radian™ 60°
3mm to 18mm
20mm long eye-relief

Plössl 50°
8mm to 55mm
"Top Rated"

Veil image courtesy of Robert Gendler.
Illustration courtesy of Roen Kelly.

Available at:

Adorama
800.223.2500

Anacortes Telescope
800.850.2001

Astronomics
800.422.7876

Oceanside Photo
800.483.6287

Telescope.com
800.303.5873

Tele Vue eyepieces deliver fields of view so naturally wide, sharp and with such high contrast, the effect has been described with one word, "Spacewalk." As the leader in eyepiece technology for over 25 years, Tele Vue continuously pushes performance boundaries using the latest materials and optical coating techniques. From design stage to final quality control inspection of every eyepiece, the details are scrutinized. Your purchase is backed with the reassurance of technically accurate personal advice just a phone call away, a 5-year product warranty, and repair service should it be necessary. Whatever telescope you use, Tele Vue eyepieces extract the best possible images from it, so you can enjoy a visual experience "even better than you imagined."

Tele Vue Optics, Inc., 32 Elkay Drive, Chester, New York 10918 845.469.4551 www.TeleVue.com

Tele Vue® Visionary

NEED ASTRO EQUIPMENT?

ASTRONOMICAL TELESCOPES

ASTRONOMICAL BINOCULARS

TRIPODS & MOUNTS

EYEPIECES & DIAGONALS

ASTRONOMICAL FILTERS

ASTROPHOTOGRAPHIC EQUIPMENT

BOOKS & STAR CHARTS

COMPUTER SOFTWARE

SOLAR OBSERVATION

OPTICAL CLEANING & CARE

SAVE UP TO 40%

EXPERT HELP

MEADE
CELESTRON
PARKS
LUMICON
TeleVue Visionary
JMI JIMS MOBILE INC
WILLIAM OPTICS
Thousand Oaks Optical
KONUS
CORONADO
Vixen
Kowa
Starry Night
SBIG
ZEISS
Nikon
Canon
FUJINON
LOSMANDY
KENDRICK ASTRO INSTRUMENTS
STELLARVUE

For All Major Brands at Discount Prices, Visit **SCOPECITY.COM**,
Any Scope City Center or Call Us Directly 800.235.3344

- SIMI VALLEY, CA 805.522.6646
- SHERMAN OAKS, CA 818.789.5805
- COSTA MESA, CA 714.957.6900
- SAN DIEGO, CA 858.277.6686
- SAN FRANCISCO, CA 415.421.8800
- LAS VEGAS, NV 702.947.2673

Scope City

The Largest And Most Complete Optical Centers In The World

www.williamoptics.com

WILLIAM OPTICS

NEW

Call for Details

FLT-132 APO F/7.0

Experience the best of the line: William Optics triplet air spaced 132mm refractor. Designed by a leading optical designer, this FPL-53 based objective boasts EXCEPTIONAL peformance.
Pure William Optics quality fit and finish: powder-painted white CNC-machined aluminum tube, golden finish, retractable dewshield, drawtube graduated scale, extra-smooth 4" focuser: a treat to use during astrophotography!

FLT-132 Specifications

Clear Aperture	132mm
Focal Ratio	F/7
Focal Length	925 mm
Objective Type	3 elements, Air-spaced, FPL-53
Resolving Power	0.86"
Limiting Magnitude	14.5

FLT-110 APO F/7.0 $2,798

Amazing 110mm refractor with 4" focuser. New improved TMB triplet air spaced lens, ideal for visual and astrophotography. Dedicated field flattener designed for FLT series optional.

TMB Field Flattener $499

ZenithStar 80 II ED Doublet APO

The newest ZenithStar II generation Doublet APO is a 80mm ED refractor ideal for everyone who needs an excellent back-up scope/guiding scope at an excellent price, or a great first APO refractor, which you can use for planetary work, wide-field imaging, and crisp, high power observations.

$528

Call for Details

Megrez 90 APO OTA

A totally new generation of refractors. Improved mechanics, amazing doublet air-spaced 90mm FPL-53 optics. Integrated dual speed Crayford Focuser. Stainless-steel reinforcement inserts for maximum load capacity. Retractable dewshield. Stylish L-bracket. Available OTA or Package.

Eazy Touch

High-quality Alt-azimuthal mount, made in Switzerland. Available with wooden tripod. $379

ZenithStar 66 SD APO

Ultra compact, true Apochromatic performance at the lowest price on the market: color-free, pinpoint star images on the super wide FOV of this f/5.9 fast refractor will blow you away. Enjoy dual speed Crayford, super high transmission coatings, carry-on case. Unique 0.8x focal reducer/field flattener available (US$ 148), together with a full series of accessories (guiding rings, extender, eyepieces, diagonals, R.D.F.)

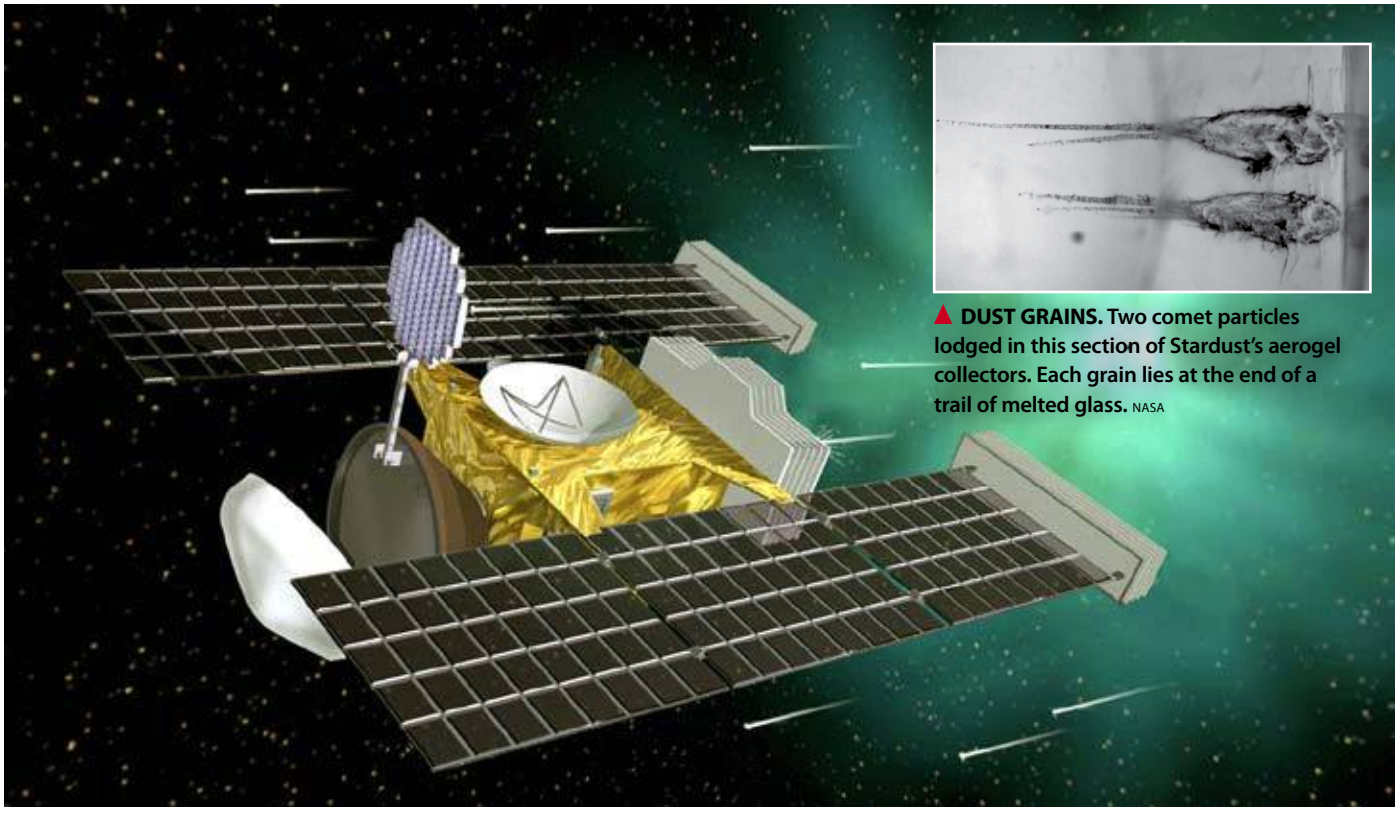
$299

wo@william-optics.com Toll Free:+1-866-918-6888 Ph:+1-714-898-7988

Negative vibe For the first time, astronomers found a negatively charged molecule (a chain of six carbon atoms with one hydrogen atom, and an extra electron) in space.

For the latest news on space discoveries, spacecraft missions, and sky events, visit **Astronomy.com/news**

Astronews



▲ **DUST GRAINS.** Two comet particles lodged in this section of Stardust's aerogel collectors. Each grain lies at the end of a trail of melted glass. NASA

NASA

STARDUST ENCOUNTER. The NASA spacecraft zips past Comet Wild 2 January 2, 2004, capturing comet particles dating to the solar system's birth.

19 Distant echo lights the sky

20 Black hole, big appetite

22 NASA announces lunar architecture

24 How to make multiple-star systems

Stardust turns the table on comet formation

Astronomers studying the microscopic particles returned from Comet 81P/Wild 2 by NASA's Stardust spacecraft characterize the first results as no less than shocking. The researchers expected to find mostly interstellar grains — tiny specks that stuck together to form the cometary material. Although they found such grains, they also discovered much larger particles made of complex minerals, many of which had been shocked and melted long ago.

Scientists had thought comets formed in the cold, outer part of the early solar system. "We are finding the hottest minerals in the coldest places," says University of Washington astronomer Donald Brownlee, principal investigator for the Stardust mission. "The major question is, 'How did they get there?'" asks Brownlee.

A slew of ideas exists, from so-called X-winds (blasts of outward energy in the early solar system) to turbulent eddies to orbital instabilities.

"Wild 2 formed from a great range of materials," adds Michael Zolensky of NASA's Johnson Space Center. "There is no evidence of liquid water with this comet," he says. Zolensky believes the mixed bag of components suggests comets act like giant vacuum cleaners.

Team members announced their findings December 14 at the American Geophysical Union meeting in San Francisco. The results also appear in the December 15 issue of *Science*.

— DAVID J. EICHER

NASA/ESA/H. BOND (STScI)

LIGHT ECHO. **Hubble's Advanced Camera for Surveys captured this view of V838 Monocerotis' vicinity, revealing complex patterns in the surrounding interstellar dust.**

Distant echo lights the sky

Light from the mysterious variable star V838 Monocerotis continues to plow through its surroundings. The Hubble Space Telescope's Advanced Camera for Surveys captured its most recent view of the spectacle in September.

The star burst into prominence in early 2002, when it temporarily brightened and became the most luminous star in our galaxy. It peaked at a luminosity some 600,000 times greater than the Sun. As light from the eruption moves outward, the surrounding dust scatters it and sends it toward Earth. This "light echo" illuminates numerous whirls and eddies in the interstellar dust. Astronomers think the intricate patterns may reflect magnetic fields surrounding V838 Mon. — **RICHARD TALCOTT**

Nature versus nurture in galaxy evolution

Are galaxies born the way they are, or do they evolve depending on their environments? A 3-year study conducted with the European Southern Observatory's Very Large Telescope shows both play critical roles.

A team led by Olga Cucciati of Brera Observatory in Italy observed 6,500 galaxies covering a range of distances — and thus, ages. The astronomers looked at how the galaxies' properties varied with age, environment, and luminosity, building an atlas of the universe going back more than 9 billion years.

"Our results indicate that environment is a key player in galaxy evolution," says team member Olivier Le Fèvre of the Astrophysical Laboratory of Marseille, France, "but there's no simple answer to the nature-versus-nurture problem." He adds: "The results suggest that galaxies as we see them today are the product of their inherent genetic information, evolved over time, as well as complex interactions with their environments."

The team announced its results December 6. — **R. T.**

QUICK TAKES

FEEDING BLACK HOLES
A team of U. K. astronomers reports in the December 7 *Nature* that supermassive black holes feed like scaled-up versions of stellar-mass black holes.

JAPAN SCRAPS LUNAR-A
Japan's space agency likely will cancel what would have been its first Moon mission, after a decade of delays left the mother ship in disrepair.

CASH FOR KECK
The National Science Foundation awarded $2 million to the Keck Observatory to improve its interferometer's sensitivity and resolution.

ESO'S BIG TELESCOPE
The European Southern Observatory will proceed with studies for a mammoth, 42-meter telescope.

ATMOSPHERIC CHANGE
Scientists say carbon-dioxide emissions from fossil-fuel burning will reduce the density of Earth's outer atmosphere 3 percent by 2017.

A COMET COMETH
Comet C/2006 P1 (McNaught) peaked at magnitude –6 in mid-January, becoming a naked-eye object in evening twilight for about a week.

MAGNETIC WHIRLPOOLS
Scientists using data from ESA's Cluster spacecraft have discovered whirlpools of electrically charged gas some 25,000 miles across (40,000 km) in Earth's magnetosphere.

POWER TO THE PEOPLE
The international consortium ITER has agreed to build a fusion reactor in France. Scientists hope it will pave the way for cleaner power.

BACTERIA IN SPACE
NASA launched GeneSat-1 December 16. The 10-pound (3.7 kg) satellite houses a living environment for bacteria.

SMALL-STAR PLANETS
Researchers have found red-dwarf stars that harbor planets contain fewer heavy elements than planet-bearing Sun-like stars. — **R. T.**

A fistful of astronomy

What's up tonight? With TheSky Pocket Edition and its database of over 252,000 objects there'll be no doubt. And, if for fun, you want to use this baby to drive your LX200, NexStar or Temma telescope system, grab a Bluetooth and go in to the night sky – wireless. Don't try that with just any software.

bisque.com

Make my night

THESKY Pocket Edition

Black hole, big appetite

NASA/JPL-CALTECH

FEEDING FRENZY. In this illustration, a star ventures too close to a supermassive black hole and is consumed.

Astronomers observing with NASA's Earth-orbiting Galaxy Evolution Explorer telescope have detected a supermassive black hole devouring a star. The feeding frenzy took place in an unnamed elliptical galaxy 4 billion light-years away in the constellation Boötes.

Suvi Gezari of the California Institute of Technology and her colleagues recorded an ultraviolet flare from the star's death throes. The black hole's immense gravity pulled the star apart before consuming it. As the matter fell into the black hole, it heated up and emitted ultraviolet light.

"This will help us greatly in weighing black holes in the universe, and in understanding how they feed and grow in their host galaxies as the universe evolves," says co-author Christopher Martin of Caltech.

These observations mark the first time astronomers have witnessed such an event from beginning to end. The findings appear in the December 10 issue of *Astrophysical Journal Letters*. — **LAURA LAYTON**

April 1982

25 years ago in *Astronomy*

Amateur astronomer Jack Marling took readers to Hawaii for some of the world's best observing in "The Incredible Skies of Mauna Kea." A vast volcanic mountain, Mauna Kea is famous for its cloud-free skies (75 percent of nights are clear), 13,800-foot elevation (4,200 meters), and extremely dark sky.

With the 24-inch U. S. Air Force Cassegrain telescope, Marling captured beautiful photographs of M4, M11, M17, M42, M57, M104, and several other galaxies, star clusters, and nebulae.

Today, Mauna Kea is home to the University of Hawaii's Institute for Astronomy, which houses 13 telescopes, including Keck I and II, Gemini North, the Subaru Telescope, and NASA's Infrared Telescope. Despite freezing temperatures and the prospect of altitude sickness, amateur and professional astronomers alike continue to consider Mauna Kea a necessary destination for observing.

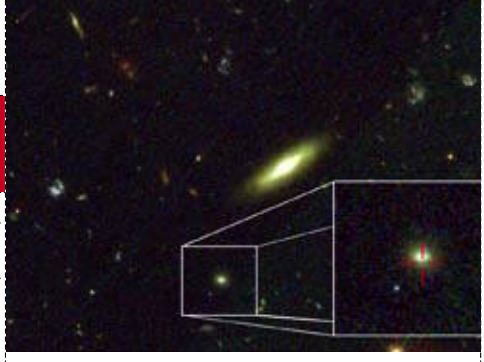
10 years ago in *Astronomy*

April 1997

In April 1997, *Astronomy* Associate Editor Robert Naeye focused on "The Strange New Planetary Zoo" of extrasolar planets. Exoplanet excitement really began, said Naeye, with Michael Mayor and Didier Queloz's 1995 discovery of a planet orbiting the Sun-like star 51 Pegasi. By early 1996, Geoffrey Marcy and Paul Butler had discovered two more exoplanets.

In April 1997, astronomers had confirmed the existence of 12 extrasolar planets; today, more than 200 have been discovered. The discovery rate has risen in the last decade thanks to advances in high-resolution spectroscopy along with the advent of gravitational-microlensing and transit-detection techniques. We've made many amazing discoveries since 1997, but Paul Butler's words continue to hold true: "We're just beginning to get a sense of how bizarre the planetary zoo is."

— **KATIE NEUBAUER**



K. SHARON AND A. GAL-YAM (CALTECH)

GAMMA-RAY BURST. The June 14 burst occurred in a galaxy (square) located 1.6 billion light-years away. The red cross-hairs indicate the burst's location.

Gamma-ray bursts: a new blast type?

Just when astronomers thought they understood how gamma-ray bursts form, two such explosions challenged their theories and hinted that massive stars may explode in more than one way.

The most powerful explosions in the universe, gamma-ray bursts come in two flavors: long bursts, which last more than 2 seconds, and short bursts, which fade away in less than 2 seconds.

Observations over the past several years led astronomers to think the long variety occurs when a massive star explodes and its core collapses to a black hole, producing a burst of gamma rays and a bright supernova. The short bursts apparently herald the merger of two neutron stars or a neutron star and a black hole, resulting in a bigger black hole but no supernova.

NASA's Swift satellite detected the new bursts May 5 (4 seconds long) and June 14, 2006 (102 seconds long). Yet follow-up observations of both long bursts revealed no subsequent supernova.

"We have lots of data and dedicated lots of observation time, and we just can't figure out what exploded," says Neil Gehrels of NASA's Goddard Space Flight Center, lead author on one of four reports published in the December 21 issue of *Nature*. "All the data seem to point to a new, but perhaps not so uncommon, kind of cosmic explosion."

The scientists speculate these bursts arose either in a new type of explosion, in which a just-born black hole swallows most of the matter from its doomed parent star, or in a new kind of merger capable of producing long bursts. **— R. T.**

Built for Astronomers by Astronomers

For over 20 years, astronomers worldwide have relied on one constant –TheSky6 Astronomy Software. While others have come and gone, innovations in TheSky6 continue to enrich your astronomy experience.

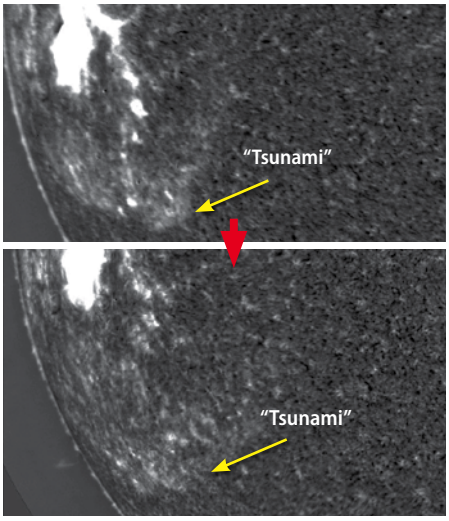
Ground breaking innovations, such as encoder-based telescope control, integrated CCD camera and telescope control, ingenious algorithms that aid in identification of celestial objects in CCD images, integrated access to the Digitized Sky Survey, and automation technology that operates robust observatories – are but a few.

Innovations that you count on, all from one source. TheSky6 Astronomy Software – the one constant that does it for you.

bisque.com

THESKY SIX
ASTRONOMY SOFTWARE

Astronomy's engine



NSO/AURA/NSF/USAF RESEARCH LABORATORY

SOLAR TSUNAMI. **A shock wave propagates across the Sun's surface. The bottom image was taken just 2 minutes after the top one.**

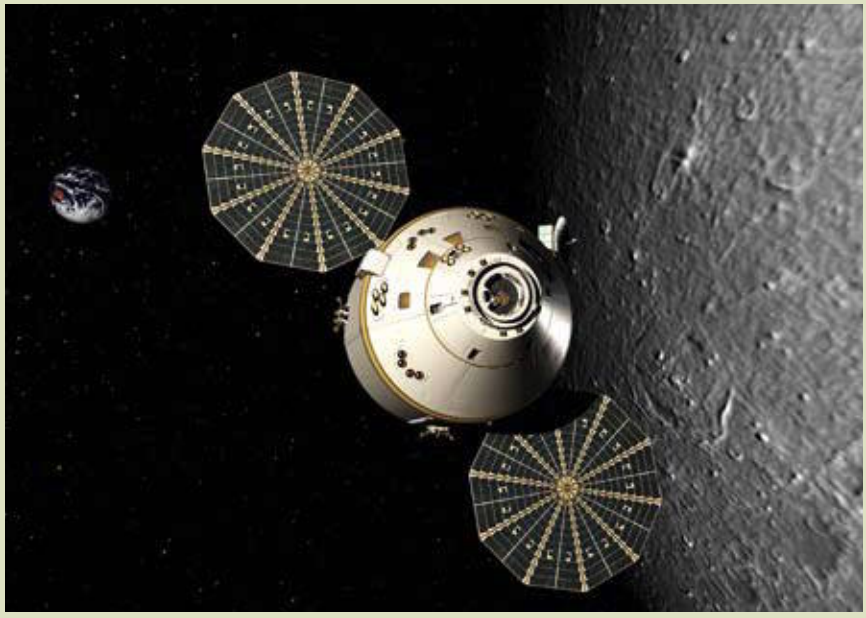
Solar "tsunami" wracks Sun

On December 6, a new solar-patrol telescope captured a tsunami-like shock wave rolling across the Sun's face. The wave followed a major solar flare and destroyed or compressed two filaments of cool gas at opposite sides of the visible hemisphere.

The National Solar Observatory's Optical Solar Patrol Network (OSPAN) telescope at Sunspot, New Mexico, monitors the Sun in Hydrogen-alpha (656.3 nanometers) as well as in white light and near-infrared. OSPAN's images clearly show a large, bright region, or plage, around a sunspot at the heart of active region 10930.

Such plages usually foretell a solar flare, and observers weren't disappointed. At 1:28 P.M. December 6, the region brightened, and a large flare blew off. A shock wave propagated like the splash from a rock thrown in a pond. The following week, another major flare from the same active region triggered bright aurorae at Earth's mid-latitudes.

Solar physicists hope to learn much from observations of the December 6 event because it occurred near solar minimum, when the wave's effects aren't partially masked by other active regions. **— R. T.**



LOCKHEED MARTIN CORP.

LUNAR ORBIT. **Sometime before 2020, the Orion Crew Exploration Vehicle will carry up to four astronauts at a time to the Moon and its polar regions.**

NASA announces lunar architecture

On December 4, NASA unveiled its plans for returning humans to the Moon by 2020. NASA planners decided the most attractive locations lie in the polar regions. Although engineering concerns played a role in the decision, astronomical factors also were fundamentally important.

First, the Moon's rotation axis lies nearly perpendicular to Earth's orbital plane — for reasons that astronomers still can't explain. This means some mountain peaks, particularly those near the south pole, remain in perpetual sunlight. Solar-energy collectors could operate continuously there to power human outposts.

The Moon's unlikely axial alignment also leaves regions on some crater floors in perpetual shadow. And, according to current theory, they have been so for at least a billion years. Such regions should serve as "cold traps" — collecting ices delivered by water-bearing comets and from outgassing elsewhere on the Moon.

A second astronomical benefit arises from the accessibility of the polar regions. For long-duration surface expeditions, the poles are the most accessible spots on the Moon for launching a spacecraft from the surface to rendezvous with an orbiting return-to-Earth vehicle.

Getting a vehicle from orbit to the surface and back again at the mission's end can be done only when the orbiting spacecraft's orbital plane crosses near the landing site. Earth's fast rotation brings a point on the surface under a satellite's orbital plane twice each day — but the Moon rotates much more slowly.

As a result, Apollo planners used so-called parking orbits tilted slightly to the Moon's equator. The command module's orbit covered the desired landing point, but was tilted enough so that a few days later, the Moon's rotation had carried the landing site back under the orbital plane.

For short missions, this is reasonable. But for longer surface stays, explorers would no longer be able to launch whenever they wanted because the Earth-return ship's orbital plane would be tilted too much. To get the landing vehicle back to orbit would require too much fuel.

Now, consider the launch window from sites near the Moon's poles. If the Earth-return vehicle is placed in a polar orbit, it passes over the poles every 2 hours or so. The orbital plane of the Earth-return craft will always be close to vehicles blasting off from either polar region.

NASA has plenty of other persuasive arguments for sending humans to the Moon's polar regions. But the astronomical and celestial mechanics' reasons are paramount — and without them, none of the other arguments would hold much weight. **— JIM OBERG**

Vixen Optics

Vixen has what you need to be whatever kind of astronomer You want to be!

The Vixen Skypod is the first portable alt-azimuth computer controlled "GoTo" mount system with an incorporated STARBOOK S hand controller. You'll never be lost in space with the built-in automatic star chart. The 22,000 object data base provides an endless variety of stars, planets, nebula and galaxies to view and is user upgradeable.

With the Vixen STARBOOK S hand controller you have the option of selecting an object for viewing by moving the star chart to the desired object and the telescope will follow or using the drop down menu and select the star, planet or galaxy from the list. Press the GOTO button and in seconds you're gazing at the universe. Because the Skypod is based on Vixens flexible mounting system, a wide variety of telescopes will easily and quickly attach to this mount. Skypod provides good portability combined with ease of use and versatility.

The VMC110L telescope shown attached to the SKYPOD is a modified Cassegrain f/9.4 optical tube. It features the same optical system as its much more expensive larger cousins the VMC200 and VMC260L. All give an image much brighter and sharper than its competition.

VixenOptics.com

VISIT OUR FACTORY AUTHORIZED DEALERS

Telescopes.com
(800) 303-5873
www.telescopes.com

Rivers Camera and Telescope
(603) 742-4888
www.riverscamera.com

Woodland Hills Telescopes
(877) 626-3233
www.telescopes.net

Oceanside Photo and Telescope
(800) 338-9638
www.optcorp.com

B&H Photo
(800) 606-6969
www.bhphoto.com

Photon Instruments
(800) 574-2589
Mesa, AZ

Enerdyne
(231) 271-6033
www.enerdynet.com

High Point Scientific
(800) 266-9590
Montague, NJ

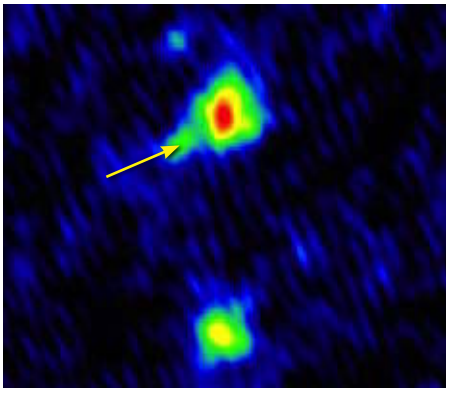
Astronomics
(405) 364-0858
www.astronomics.com

Adirondack Video Astronomy
(518) 747-4141
www.astrovid.com

Sean's Astronomy Shop
(360) 666-6882
Battle Ground, WA

Land Sea and Sky
(713) 529-3551
Houston, TX

Kendrick Astro Instruments
(416) 762-7946
Toronto, Canada



J. LIM AND S. TAKAKUWA/NRAO/AUI/NSF

BREAKING AWAY. **A small protostar (arrow) seems to fragment from the larger of two protostars in star system L1551 IRS5.**

How to make multiple-star systems

Observations of multiple-star system L1551 IRS5 suggest such systems form when protostars and their cocoon-like disks of dust and gas break away from a parent disk. This fragmentation model explains why the disks of the system's two main protostars align with each other and with a larger, surrounding disk.

Jeremy Lim of the Institute of Astronomy and Astrophysics, Academia Sinica, in Taipei, Taiwan, and Shigehisa Takakuwa of the National Astronomical Observatory of Japan observed L1551 IRS5 with the Very Large Array radio telescope in Socorro, New Mexico. To increase resolution, the scientists added an antenna from the Very Long Baseline Array in Pie Town, New Mexico. Their study appears in the December 10 issue of *The Astrophysical Journal*.

Ironically, the observations also revealed a third protostar in the system — this one with a misaligned disk. "The misalignment of the third protostar and its disk leaves open the possibility that it could have formed elsewhere and been captured," says Lim.

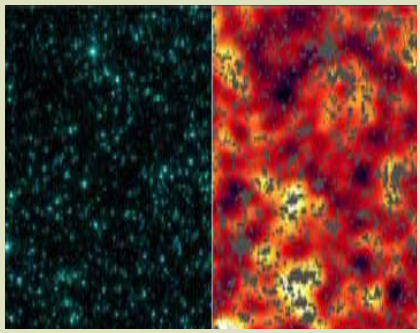
Studies of multiple-star systems like the 450-light-year-distant L1551 IRS5 are important because they are more prevalent than single-star systems. **— L. L.**

Catching up with the early universe

Astronomers studying the cosmic infrared background with the Spitzer Space Telescope believe they have detected light from some of the first objects to form in the universe. These objects may be black holes caught in the act of feeding or gigantic stars with 1,000 times the Sun's mass clustered in mini-galaxies with masses of less than 1 million Suns.

"Whatever these objects are, they are intrinsically incredibly bright and very different from anything in existence today," says Alexander Kashlinsky of NASA's Goddard Space Flight Center in Greenbelt, Maryland. Kashlinsky led the Spitzer team that discovered the light in a single region during a 2005 study of the cosmic infrared background. The team reports on new observations of four more regions in papers set to appear in *Astrophysical Journal Letters*.

Data gathered during the new Spitzer observations will help scientists further probe the early universe and learn about the earliest structures. The James Webb Space Telescope, scheduled for launch in 2013, should be able to observe the first stars and galaxies directly. **— L. L.**



NASA/JPL-CALTECH/GSFC

EARLIEST GLOW. **The Spitzer Space Telescope took this infrared image showing part of Ursa Major (left). After removing foreground objects, the leftover light (right) reveals the universe's first objects.**

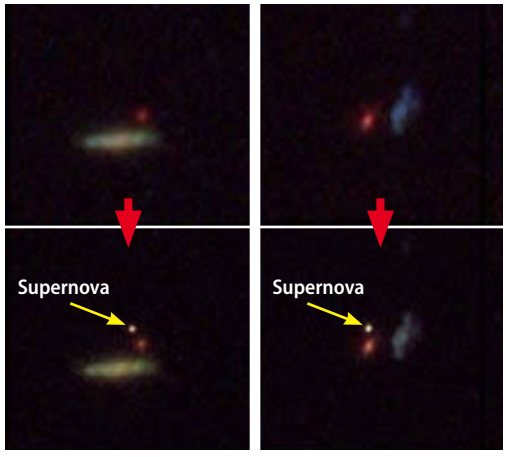
BRIEFCASE

Hot Venus

The European Space Agency's Venus Express spacecraft has completed the first large-area temperature maps of Venus' southern hemisphere. The results, reported December 14 at the American Geophysical Union's meeting in San Francisco, show the lowlands to be 54° F (30° C) hotter than the mountain tops. **— R. T.**

Honest science

The Council of Science Editors published a white paper on scientific integrity in December. The publication responds to a recent spate of scientific falsifications, notably that of South Korean stem-cell researcher Woo Suk Hwang. About half of the white paper is devoted to research misconduct: what it is, how to identify it, and what an editor or peer should do about it. **— L. L.**



NASA/ESA/A. RIESS (STScI)

DARK UNIVERSE. **Exploding supernovae are a gauge by which astronomers measure the universe's expansion rate.**

Dark energy isn't new energy

Astronomers using Hubble Space Telescope images of exploding supernovae to measure the universe's expansion rate have found an intriguing result: Dark energy, which contributes to the expansion of the universe, existed at least 9 billion years ago.

Because all type Ia supernovae have about the same peak luminosity, scientists use them to track the universe's expansion rate. "Although dark energy accounts for more than 70 percent of the energy of the universe, we know very little about it, so each clue is precious," says Adam Riess of the Space Telescope Science Institute and Johns Hopkins University in Baltimore. **— L. L.**

Turning the Odds in Your Favor

Probability has never been more interesting and accessible than in these 12 lectures from The Teaching Company

Every time you buy stock or make plans based on a weather forecast, you are consigning your fate to probability.

What Are the Chances? Probability Made Clear helps you understand the random factors behind almost everything—from the combinations of genes that produced *you* to the high odds that the waiting time at a bus stop will be longer than the average time between buses.

Probability as a Reasoning Tool

Professor Michael Starbird knows the secret of making numbers come alive to nonmathematicians. He picks intriguing, useful, and entertaining examples, with questions such as: When did the most recent common ancestor of all humans live? How much should you pay for a stock option? What do you do on third down with long yardage?

After an introduction to the fundamental concepts of probability, you delve into a wealth of applications. Lectures 5 and 6 show that randomness and probability are central to physics and biology. Lecture 7 investigates the world of finance, particularly probabilistic models of stock and option behavior. Lecture 8 explores some unexp cted applications of probability, and Lecture 9 examines two famous probability puzzles guaranteed to cause a stir: the birthday problem and the *Let's Make a Deal*® Monty Hall question.

Finally, Lectures 10 through 12 cover increasingly sophi ticated and surprising results of probabilistic reasoning associated with Bayes theorem. The course concludes with probability paradoxes, including the notorious St. Petersburg paradox, involving a simple lottery in which the expected value is infinity; something has to be wrong, but can you guess what it is?

$$p \times 5 + (1 - p) \times 6 = p \times 7 + (1 - p) \times 1$$

$$(1 - p) \times 5 = p \times 2$$

$$5 = p \times 7$$

$$p = \frac{5}{7} = 0.714$$

The Teaching Company Collection.

Surprisingly, probability can be used to make a variety of decisions—one example is football. Here, p is the probability of the offensive team passing the football on 3rd and long yards.

About Your Professor

Professor Michael Starbird is a distinguished and highly popular teacher with an uncommon talent for making the wonders of mathematics clear. He is Professor of Mathematics and a Distinguished Teaching Professor at The University of Texas at Austin, where he has received the Pqesident's Associates Teaching Award, the Jean Holloway Award for Teaching Excellence, and the Friar Soc ety Centennial Teaching Fellowship.

About The Teaching Company

We review hundreds of top-rated professors from America's best colleges and universities each year. From this extraordinary group we choose only those rated highest by panels of our customers. Fewer than 10% of these world-class scholar-teachers are selected to make The Great Courses. We've been doing this since 1990, producing more than 2,000 hours of material in modern and ancient history, philosophy, literature, fine arts, the sciences, and mathematics for intelligent, engaged, adult lifelong learners. If a course is ever less than completely satisfying, you may exchange it for another, or we will refund your money promptly.

Lecture Titles

1. Our Random World—Probability Defined
2. The Nature of Randomness
3. Expected Value—You Can Bet on It
4. Random Thoughts on Random Walks
5. Probability Phenomena of Physics
6. Probability Is in Our Genes
7. Options and Our Financial Future
8. Probability Where We Don't Expect It
9. Probability Surprises
10. Conundrums of Conditional Probability
11. Believe It or Not—Bayesian Probability
12. Probability Everywhere

About Our Sale Price Policy

Why is the sale price for this course so much lower than its standard price? Every course we make goes on sale at least once a year. Producing large quantities of only the sale courses keeps costs down and allows us to pass the savings on to you. This approach also enables us to fill your order immediately: 99% of all orders placed by 2:00 p.m. eastern time ship that same day. Order before April 27, 2007, to receive these savings.

THE TEACHING COMPANY®
The Joy of Lifelong Learning Every Day™
GREAT PROFESSORS, GREAT COURSES, GREAT VALUE GUARANTEED.®

SAVE $160!
OFFER GOOD UNTIL APRIL 27, 2007

1-800-TEACH-12 (1-800-832-2412)
Fax: 703-378-3819

Special offer is available online at
www.TEACH12.com/6astr

The Great Courses®
THE TEACHING COMPANY®
4151 Lafayette Center Drive, Suite 100
Chantilly, VA 20151-1232

Priority Code 22451

Please send me **What Are the Chances? Probability Made Clear**, which consists of 12 half-hour lectures (6 hours in all) and a Course Guidebook.

❑ **DVD $39.95** (std. price $199.95) **SAVE $160!**
plus $5 shipping, processing, and lifetime satisfaction guarantee.
Special price for shipping, processing, and lifetime satisfaction guarantee—this offer only.

❑ **Check or Money Order Enclosed**

* Non-U.S. Orders: Additional shipping charges apply. For more details, call us or visit the FAQ page on our website.
**Virginia residents please add 5% sales tax.

Charge my credit card:

❑ VISA ❑ MasterCard ❑ Discover ❑ American Express

ACCOUNT NUMBER EXP. DATE

SIGNATURE

NAME (PLEASE PRINT)

MAILING ADDRESS

CITY/STATE/ZIP

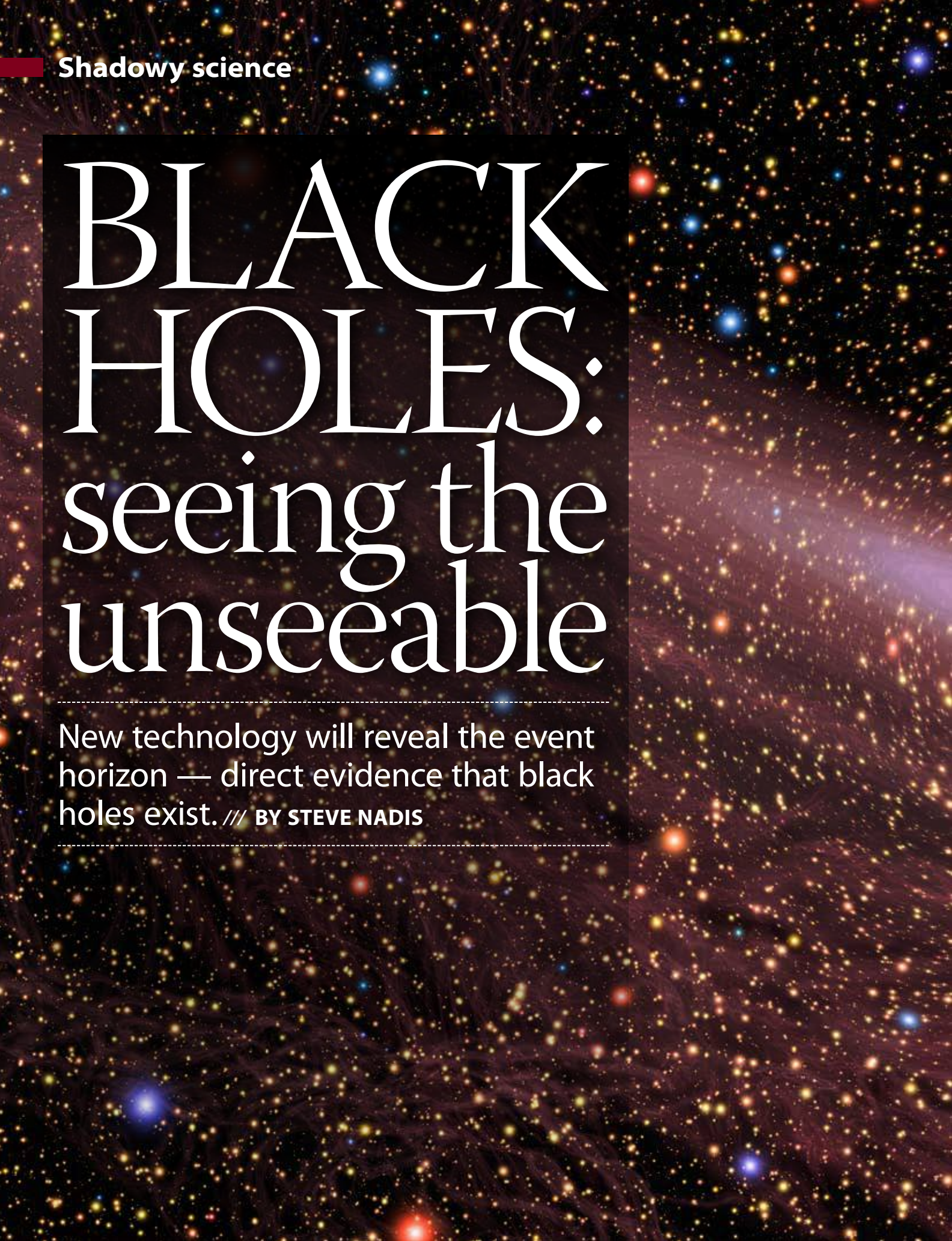
PHONE *(If we have questions regarding your order—required for international orders)*

❑ **FREE CATALOG.** Please send me a free copy of your current catalog (no purchase necessary).

Special offer is available online at www.TEACH12.com/6astr
Offer Good Through: April 27, 2007

BLACK HOLES: seeing the unseeable

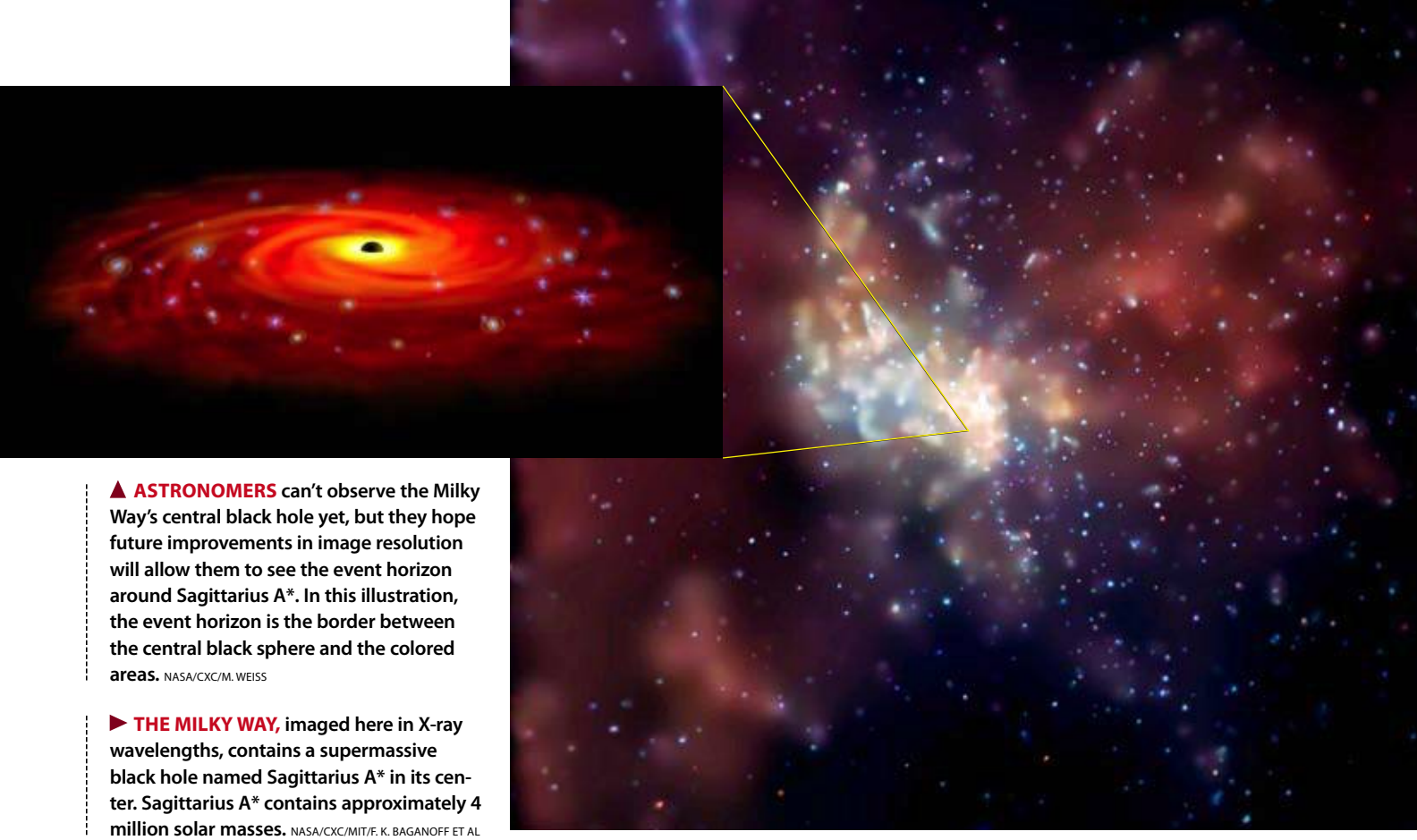
New technology will reveal the event horizon — direct evidence that black holes exist. /// **BY STEVE NADIS**



The first known discussion of black holes appeared in a 1783 paper written by British geologist and natural philosopher John Michell (1724–1793). He speculated about stars so massive, and with such intense gravitational fields, their escape velocities (the minimum speed necessary for an object not to be trapped by the star's gravity) would exceed the speed of light. These objects would remain invisible, with their light trapped forever inside, swallowing any matter and radiation that ventured too close.

It took nearly 200 years before experimental support for Michell's wild conjecture started coming in, although the idea got a big theoretical boost in 1915 with the advent of Albert Einstein's theory of general relativity. Today, most astrophysicists believe black holes exist. Nonetheless, the evidence remains circumstantial. Measurements of star motions caught in a putative black hole's grip support the theory. So do observations of the

THE EVENT HORIZON of a black hole appears dark against a bright maelstrom of swirling gas and infalling matter. Astronomers hope to image the event horizon of the Milky Way's supermassive black hole. ADOLF SCHALLER FOR *ASTRONOMY*



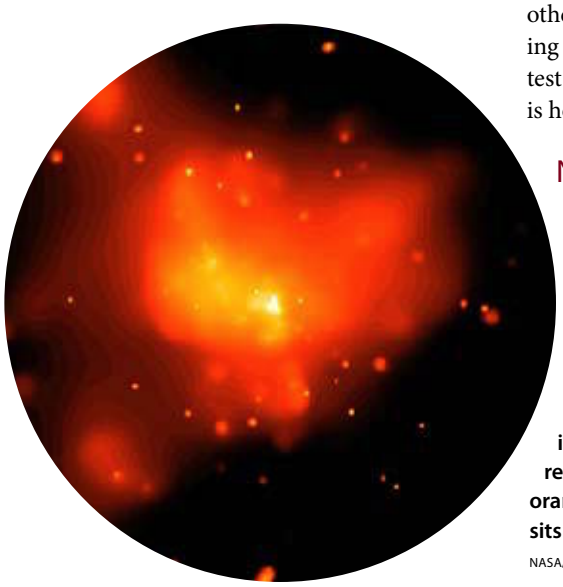
▲ **ASTRONOMERS can't observe the Milky Way's central black hole yet, but they hope future improvements in image resolution will allow them to see the event horizon around Sagittarius A*. In this illustration, the event horizon is the border between the central black sphere and the colored areas.** NASA/CXC/M. WEISS

▶ **THE MILKY WAY, imaged here in X-ray wavelengths, contains a supermassive black hole named Sagittarius A* in its center. Sagittarius A* contains approximately 4 million solar masses.** NASA/CXC/MIT/F. K. BAGANOFF ET AL

radiation emitted by ultrahot gas drawn toward the black hole's gravitational abyss.

Past the horizon

Seeing a black hole would go a long way toward removing doubt. But can we see an object that is, by definition, unseeable? Perhaps not. Astronomers are confident, however, that we can detect signs of a black hole's defining feature: the event horizon. This conceptual boundary surrounds the object, and nothing, not even light, can escape from within it.



SAGITTARIUS A* is our galaxy's central black hole. This Chandra X-ray Observatory image shows the relationship between the black hole and the surrounding supernova remnant, Sagittarius A East. Emissions from the supernova remnant show up as yellow and lighter orange tones at the image's center. Sgr A* sits near the bright white dots at center. NASA/PENN STATE/G. GARMIRE ET AL.

The event horizon marks the point of no return: Anything crossing the dotted line won't be coming back. Event horizons stand at the limit of the observable universe — portals into unknown realms where the laws of physics may deviate substantially from those prevailing on the other side.

Finding the event horizon would help prove something's a black hole and not just a massive, compact object. If an object has an event horizon, it is a black hole — a surfaceless, bottomless pit. If, on the other hand, the object has a surface, it is some other entity yet to be determined. Detecting the event horizon is, therefore, a litmus test for black holes. The trouble, once again, is how can you see an abstraction?

Not a shadow of doubt

"The event horizon is a funny thing because it's not a physical object," admits University of Maryland astronomer Christopher Reynolds. "The only way to see it is to see the absence." In other words, Reynolds says, it's finding a dearth of emissions in places you expect an abundance. This absence would show up as a shadow bounded by a luminous ring.

The shadow — a dark circle, set against a bright background — forms when radiation from superhot gas swirling behind the black hole crosses the event horizon. The shadow looks bigger than the event horizon's diameter because the black hole bends light waves toward it — a trick called gravitational lensing.

The ring is another gravitational-lensing effect, akin to "Einstein rings" that form when two galaxies align, one directly behind the other. In the black hole's case, the ring is produced by light emanating from hot gas behind the black hole that skirts the event horizon.

The ring may look more like a crescent than a circle, depending on the black hole's spin, explains Eric Agol of the University of Washington. He ran some of the first computer simulations of these features with Heino Falcke of the Max-Planck Institute and Fulvio Melia of the University of Arizona. "You may not see the faintest parts of the ring, but you need to be able to see

some parts of it to map out the shadow's full extent," says Agol.

Where and how to search

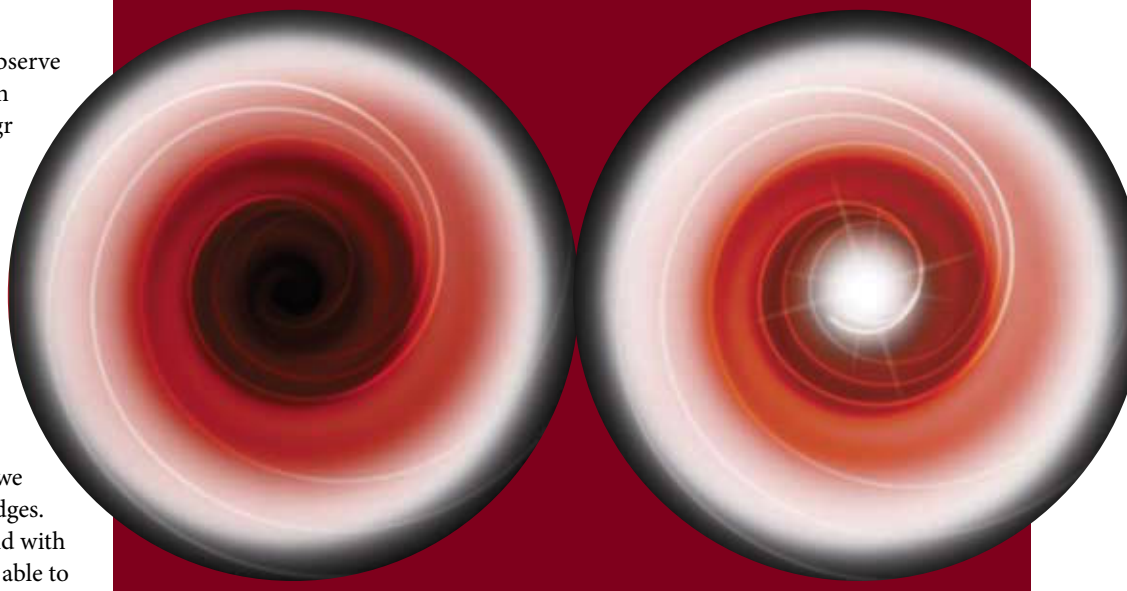
Astronomers' best opportunity to observe a black hole's ring and shadow lies in our galaxy's center, buried within Sgr A* (pronounced "Sagittarius A star") — a radio source long believed to harbor a supermassive black hole. The ring's diameter, according to the latest calculations, measures about 30 microarcseconds, or 0.00012°, according to Reynolds. This size compares to seeing a tennis ball on the Moon from Earth. The shadow and ring are on smaller scales than we can currently observe, he acknowledges. "We've already seen a fuzzy view, and with improving resolution, we should be able to make out the structures themselves."

At present, there's just one tool that approaches the requisite precision — the Very Large Baseline Array (VLBA). The VLBA is a system of 10 radio telescopes linked to create an interferometer that stretches from Hawaii to the Virgin Islands. A telescope's resolving power is proportional to its size; the bigger the telescope, the smaller the features it can discern. With a baseline of more than 5,000 miles (8,000 km), the VLBA offers the sharpest vision of any telescope on land or in space.

Using this network to observe, a team headed by Zhi-Qiang Shen of Shanghai Observatory furnished the most detailed images yet of our galactic center. These images showed Sgr A* has a mass of 4 million Suns confined to a region 1 astronomical unit (the distance between the Sun and Earth) wide. This huge concentration of mass leaves little doubt that Sgr A* contains a supermassive black hole.

THE CHANDRA X-ray Observatory, launched in July 1999, observes high-energy X rays from objects such as supernovae. Astronomers are using Chandra data to find event horizons by indirect means, such as comparing assumed black holes with neutron stars. NASA/CXC

One difference between black holes and neutron stars



GAS SWIRLING onto a black hole disappears from view when it crosses the event horizon. Because the black hole has no surface, the central region is black. NASA/CXC/M. WEISS

GAS FLOWING onto a neutron star becomes part of the star. When the gas strikes the neutron star's solid surface, however, it glows brightly. NASA/CXC/M. WEISS

"We can now see to within about 10 times the Schwarzschild [event horizon] radius," says Fred Lo, the National Radio Astronomy Observatory director who collaborated with Shen. "We need another tenfold increase in resolution to get to the event horizon itself."

One way to boost resolution is to put a telescope in space that connects with the ground-based system, thereby extending the baseline dramatically. NASA's Advanced Radio Interferometry between Space and Earth (ARISE) mission and Japan's next-generation VLBI Space Observatory Programme (VSOP-2) both are designed for this purpose, although neither mission has secured funding.

Parting the fog

In the meantime, there is much to be done from the ground. The main goal, at present, is to observe at shorter wavelengths, pushing into the submillimeter regime. This would not only improve the angular resolution (which is proportional to wavelength), it also would help with two other vexing problems: First, scientists expect the gas orbiting a black hole is transparent at wavelengths of about 1 millimeter or less. Second, electrons from the ionized gas between us and the galactic center scatter radio waves as they propagate through our galaxy, creating a blurring effect. "It's like looking at a headlight in the fog," says Lo. "You see the glow but not the headlight."

Fortunately, the blurring shrinks at shorter wavelengths. At around 1 millimeter, says Agol, "The blurring becomes smaller than the angular size of the black hole, which makes it possible to resolve the event horizon."

The current VLBA never will achieve the necessary resolution; a separate global network of higher-frequency microwave telescopes is needed instead. Thus, astronomers might link the Atacama Large Millimeter Array (ALMA) being built in Chile with submillimeter telescopes in North America. Interferometry, however, gets harder at smaller wavelengths, notes Geoffrey Bower of the University of California, Berkeley, because "All the technical tolerances scale with wavelength."

Antenna surfaces have to be more accurate, and phase correlation becomes more difficult. "Although the experiments are technically demanding, they are not overly

Steve Nadis *is a science writer living in Cambridge, Massachusetts, and is a contributing editor for* Astronomy.

expensive, since we don't need any new telescopes," Bower adds. Putting together an "ad-hoc array" would cost only a few million dollars, he estimates. Despite keen interest among black-hole hunters, the concept is still unfunded.

Lo expects observational astronomers to reach their target, the event horizon around the Milky Way's black hole, within 10 years. After spending 3 decades trying to get there, he can almost see the "headlight" at the end of the tunnel.

The black hole at the center of elliptical galaxy M87 in Virgo will be next on the list. It's about half the angular size of our galaxy's black hole, being roughly 1,000 times bigger and 2,000 times farther away. Other black holes, which will appear even smaller, will be harder to pick out.

But seeing just one event horizon — that surrounding our galaxy's black hole — will be a major accomplishment in its own right. Such an observation will provide proof that black holes exist. "The evidence is already compelling," says Lo, "but this would really nail it."

Beyond that, observations of the shadow and ring around a black hole — structures predicted by Einstein's theory of general relativity — will afford astrophysicists unprecedented opportunities to test that theory in the so-called strong-field limit. That's an environment where general relativity's effects are dominant rather than subsidiary. By measuring the shadow's size and shape, researchers can determine the black hole's size and spin.

Resolving an event horizon, in other words, will supply a wealth of information about black holes and the theory that describes them. An extraordinary set of coincidences could make this possible, Agol says. First, our galaxy's black hole had to be big enough, and close enough, to make its angular size large enough to be seen. Second, we live on a planet where baselines of more than 5,000 miles (8,000 km) are possible. Third, gravity bends light so strongly, it magnifies the shadow by a factor of 2.5.

"That extra 2.5 makes a big difference in our ability to resolve the event horizon," Agol says. Then there's the fact that at wavelengths between 0.3 and 1 millimeter, all sorts of magical things happen: Our atmosphere allows the transmission of radio waves, the gas around a black hole may become transparent, and electron-scattering in the interstellar media declines demonstrably. "All these ingredients combine to make this a plausible experiment," Agol concludes, provided nature cooperates and doesn't throw us any nasty curves.

IF YOU CAN SHOW an object has an event horizon, you've sealed its identity as a black hole.

"It is a lucky coincidence that we can resolve the event horizon [in Sgr A*]," agrees Harvard astronomer Ramesh Narayan. "It didn't have to work out that way, and there certainly are black holes we'll never be able to resolve. But we may not be as lucky as Eric [Agol] thinks."

Computer simulations of Sgr A* by Agol's Harvard colleagues, Avery Broderick and Avi Loeb, suggest hot spots analogous to solar flares in the gas orbiting the black hole may be so bright as to make the shadow and ring harder to detect than anticipated. Separate research by Broderick and Narayan indicates submillimeter imaging alone may not distinguish between a black hole in the galactic center and some other compact object. Infrared imaging also would be needed to show whether the gas accreting onto the object ever hits a surface, with the energy from that impact later released as heat. "It will take measurements of many different wavelengths to figure this out," Agol concedes.

Narayan advocates a big push for infrared (IR) interferometry. Astronomers at Keck Observatory in Hawaii and the European Southern Observatory's Very Large Telescope are making progress on this front. "We have the potential to see the same things in IR — the shadow and event horizon — that others hope to see with submillimeter and, eventually, X-ray arrays," notes Andrea Ghez of UCLA.

The Black Hole Imager, a proposed space-based X-ray interferometer, offers the prospect of an angular resolution 100 times more detailed than a microwave instrument could provide. The advantage comes from the exceedingly small wavelengths of X rays (on the order of a nanometer), a factor that simultaneously makes the engineering task all the harder. That's why the Black Hole Imager is 20 or more years off, assuming the financing comes through.

The future is now

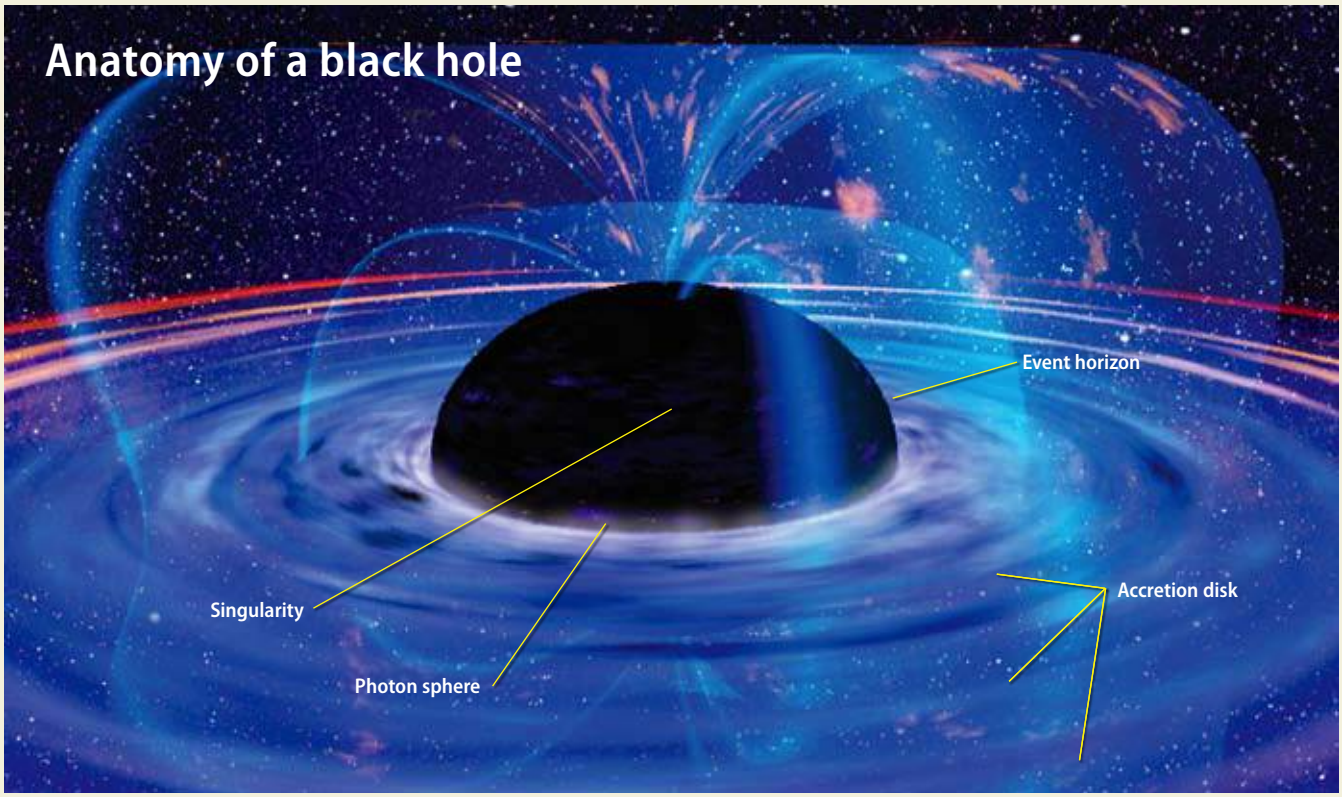
But we don't have to wait decades for answers. Existing X-ray facilities like the Rossi XTE and Chandra X-ray Observatory are helping unravel event horizons. "The event horizon, according to theory, swallows up everything, with no signals coming out," says Narayan. So how do you see it?

He suggests an indirect approach — comparing an assumed black hole with something that doesn't have a horizon, such as a neutron star. The kinetic energy of matter accreting onto a neutron star will be reradiated back into space.

When a black hole takes in matter, however, there is no surface for it to strike. Instead, the matter sinks toward the singularity in the object's center, where the pull of gravity is infinitely strong.

Michael Garcia, Narayan, and other colleagues at the Harvard-Smithsonian Center for Astrophysics documented this effect in 2001. Using Chandra data, they showed neutron stars in quiescent "feeding mode" — with a gentle "rain" of matter settling on them — emitted 100 times more energy

INTERFEROMETRY offers the best hope to observe an event horizon. The Very Long Baseline Array (VLBA) combines 10 radio telescopes as an interferometer that stretches from Hawaii to the Virgin Islands. The dish shown here operates in Owens Valley, California. NRAO



Accretion disk — Matter (usually gas) captured by a black hole's gravitational pull; as the gas swirls toward the black hole, friction makes the gas glow and emit energy. Near the event horizon, accretion-disk material moves rapidly and emits X rays.

Event horizon — A black hole's gravitational boundary, where the escape velocity equals the speed of light. Any object passing through the event horizon will disappear forever, and no object within the event horizon is observable from outside.

Photon sphere — A bright region surrounding the black hole where any light created must be directed outward to escape the black hole's gravity. The photon sphere's radius equals 1.5 times the radius of the event horizon.

Singularity — A black hole's central point, where all matter ends up and both the curvature of space-time and the density are infinite. This point is unobservable. The singularity's mass defines the size of the black hole's event horizon.

than dormant black holes. "Watching matter flowing into a black hole is like sitting upstream of a waterfall and watching the water seemingly vanish over the edge," Narayan remarks. "However, replace the waterfall by a dam — the analog of a neutron star's surface — and the water would pile up and one would see a mighty lake."

Those findings, however, were controversial. Critics claimed the black holes might shed their energy in other ways — through astrophysical jets, for instance — in which case the results wouldn't prove the existence of event horizons. So Narayan and Jeremy Heyl (now at the University of British Columbia) devised a less equivocal test: looking at neutron-star and black-hole candidates actively feeding on companion stars. Gas from a companion star would accumulate on a neutron star's surface and ignite about once a day in minute-long thermonuclear explosions called type-1 X-ray bursts. Black holes, which lack a surface where gas can accumulate, would exhibit no such behavior.

A 2005 study headed by Ron Remillard of MIT explored this idea. The team examined 31 Rossi XTE sources — 13 suspected neutron stars and 18 suspected black holes — and detected 135 bursts from the candidate neutron stars and none from the black-hole candidates. "A score of 135 to 0 is about as clear as can be," comments Narayan, who contributed to the analysis. "It's pretty obvious that the black-hole candidates don't have surfaces. You can always concoct some far-out model to explain the results, but I think it'll be very hard to come up with a counter-argument that does not involve horizons."

As astronomers close in on event horizons in the radio band, other investigators gather clues at the X-ray end of the spectrum. And the event horizon — a concept that has captivated us for decades — may soon complete the transition from myth to reality. "At the end of the day," says Narayan, "it all adds up to a very strong story."

It's been a long journey for black holes, going from the theoretical oddities first proposed more than 2 centuries ago to entities that, despite their weirdness, are becoming harder to deny. Once researchers secure the final bit of evidence — the hallmark feature of these peculiar objects, namely their event horizons — the existence of black holes will become a virtual certainty. And publishers might one day adorn astronomy textbooks with a glimpse of the invisible: a picture of a black hole.

ONLINE EXTRA View a black-hole simulation at www.astronomy.com/toc.

New Horizons *flies past* Jupiter

Bound for Pluto, the New Horizons spacecraft gets the closest look at Jupiter and its moons in four years.

/// BY S. ALAN STERN

NEW HORIZONS received a speed boost as a result of its encounter with Jupiter. JUPITER: NASA/JPL/SSI; SPACECRAFT: JHUAPL/SWRI

New Horizons —the first mission to Pluto and the Kuiper Belt — rocketed into space January 19, 2006. Now, just over a year into its flight, the spacecraft nears Jupiter, where the giant planet's gravity will give it an additional 9,000 mph (14,400 km/h) speed boost. The encounter offers scientists a chance to learn more about Jupiter and its moons, but it also serves as practice for the mission's fast Pluto flyby in 2015.

Speeding to a giant

New Horizons' 13-month journey from Earth to Jupiter sets a new speed record. It shaves 3 months off the previous record, held by the Ulysses solar orbiter in 1992. NASA's Saturn-bound Cassini spacecraft performed the most recent Jupiter flyby in 2000. This followed gravity-assist detours past Venus and Earth, which lengthened its Jupiter journey by a factor of 3.

New Horizons will do more than just get a speed boost from Jupiter. From January through June, the craft will flex its muscles in an encounter that promises to tell us something new about the jovian system.

Alan Stern, *the principal investigator of the New Horizons mission, is a planetary scientist at the Southwest Research Institute in Boulder, Colorado.*

NEW HORIZONS' SCIENCE SUITE

New Horizons' primary instruments are Ralph and Alice, named for the main characters in the 1950s television show *The Honeymooners*. Ralph is a mapping camera combined with an infrared spectrometer. It's designed to detect surface compositions and temperatures. Alice, an ultraviolet spectrometer, examines the opposite spectral region. It will study the structure and composition of Pluto's — and Jupiter's — upper atmosphere.

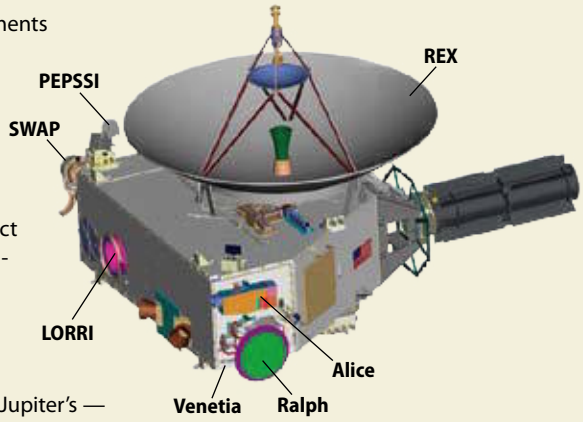
Another camera, called LORRI — for Long Range Reconnaissance Imager — is less versatile than Ralph but offers higher resolution. LORRI lets New Horizons study its targets from much greater distances than Ralph does and will provide the most detailed images during flybys. Ralph, Alice, and LORRI can do their jobs even though the sunlight on Pluto is about 1,000 times weaker than on Earth.

New Horizons also carries two plasma sensors, called PEPSSI and SWAP, which will study electrically charged gases escaping the atmospheres of Jupiter and Pluto.

A radio science experiment named REX will probe the temperature and pressure of both planets' lower atmospheres and measure the masses of Pluto, Charon, and any Kuiper-Belt objects encountered.

New Horizons also carries the first student-designed planetary-science instrument. The Venetia Bradley Student Dust Counter (Venetia), built at the University of Colorado, will measure dust densities across the outer solar system for the first time.

These instruments promise to make the exploration of Pluto, Charon, and the Kuiper Belt a scientific watershed. — *S. A. S.*



NEW HORIZONS' seven instruments range from cameras to a dust counter.
ASTRONOMY: ROEN KELLY

But the seven-instrument scientific payload New Horizons carries wasn't designed for Jupiter science. It was built to address the specific objectives of first-time reconnaissance at Pluto and the Kuiper Belt objects (KBOs) beyond. But the probe's instrument suite provides a wide range of capabilities for studying the solar system's largest planet.

Three instruments — named Ralph, Alice, and LORRI — form the remote-sensing part of the payload. Ralph combines a multicolor imager with a composition-mapping infrared spectrometer. Alice is an ultraviolet imaging spectrometer designed primarily for probing the composition and structure of planetary atmospheres. LORRI — the Long-Range Reconnaissance Imager — takes monochrome images with much higher resolution than Ralph.

A second instrument trio will investigate the flux of dust particles and ionized gas New Horizons flies through. It includes the Venetia Burney Student Dust Counter (Venetia, for short), named for the then 11-year-old English girl who, in 1930, proposed Pluto as the name for the ninth planet. Venetia counts the number of dust particles striking the spacecraft and determines the mass of each impactor.

Two space-plasma spectrometers — Solar Wind Around Pluto (SWAP) and Pluto Energetic Particle Spectrometer Science Investigation (PEPSSI) — round out this group. Together, they measure the flow and composition of low-, medium-, and high-energy charged particles in space. Although designed to "sniff out" escaping material from Pluto's upper atmosphere, SWAP and PEPSSI also can study the ionized gases trapped in Jupiter's magnetosphere, a vast, teardrop-shaped region surrounding the planet.

A radio experiment called REX rounds out New Horizons' science payload.

Swinging by Jove

New Horizons approaches Jupiter no closer than some 32 Jupiter radii — 1.4 million miles (2.3 million kilometers). The craft must fly the one and only trajectory that puts it on the fastest course to Pluto, which is what determines this closest-approach distance and its position relative to Jupiter. The spacecraft cannot come closer to study Jupiter and its moons at smaller range — as the Voyager and Pioneer missions did — without missing the Pluto aim point. And, unfortunately, the four large Galilean satellites — Io, Europa, Ganymede, and Callisto — all lie on the opposite side of Jupiter.

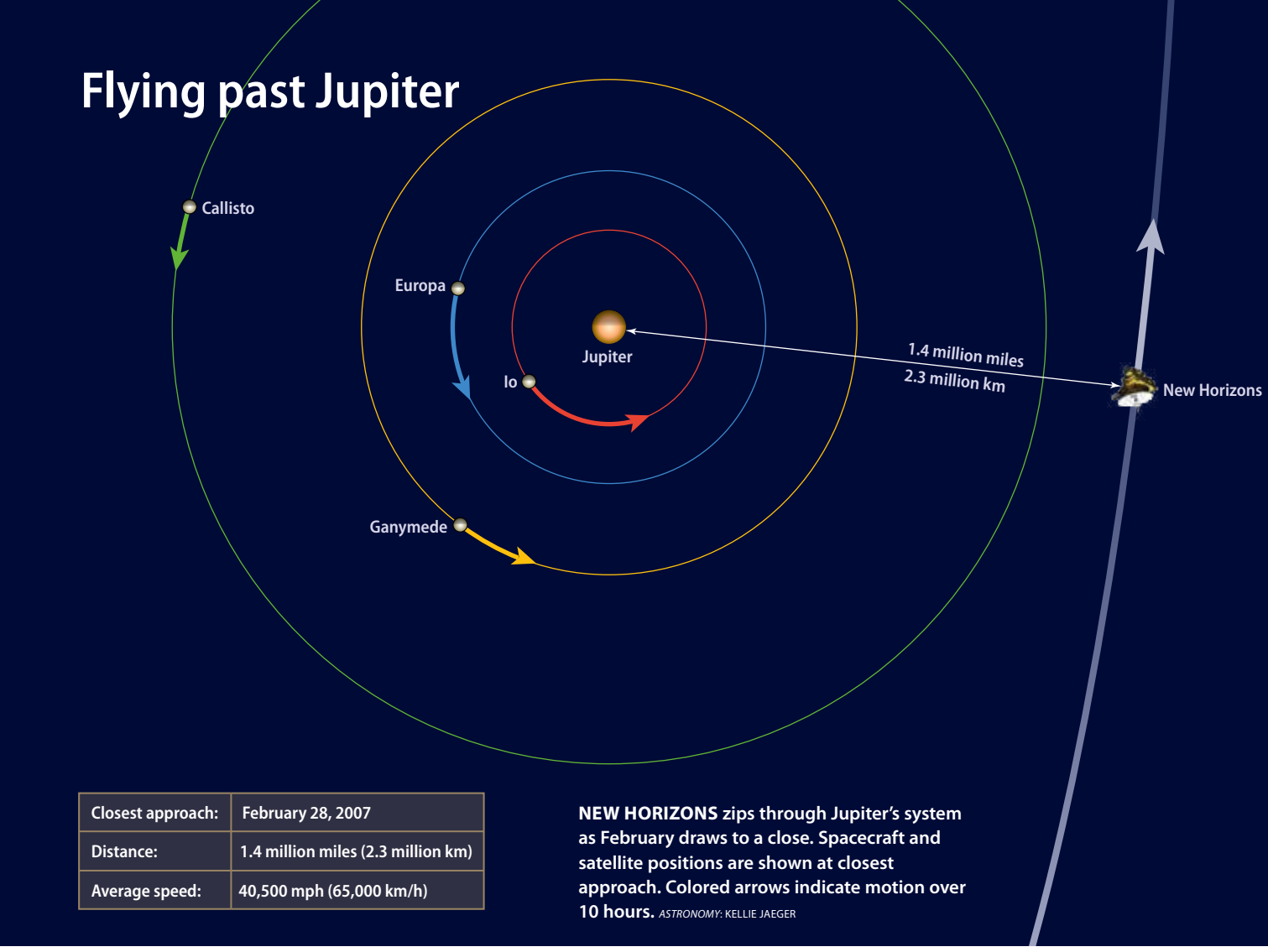
However, thanks to the relative positions of Jupiter and Pluto, this gravity assist propels New Horizons directly behind Jupiter, with almost no bending of the trajectory as the spacecraft recedes from the planet. As a result, New Horizons will fly directly down Jupiter's magnetotail, the gigantic portion of the planet's charged-particle-trapping "magnetic bubble" that stretches out behind it. For nearly 4 months, the spacecraft's plasma and dust-particle instruments will map Jupiter's magnetotail.

This marks a first for the exploration of any giant planet. New Horizons will operate SWAP, PEPSSI, and Venetia virtually around the clock throughout March, April, May, and June as it flies down the magnetotail.

Scientists think the magnetotail's whole structure billows and flaps like a giant windsock in response to changes in the solar wind, but the detailed dynamics are unknown. Far from Jupiter, the magnetotail probably twists and turns violently. New Horizons likely will pass in and out of the magnetotail several times as it heads out of the system. With luck, however, the craft may sample the magnetotail as far as 1,000 Jupiter radii (48 million miles, or 78 million kilometers) "downstream."

NEW HORIZONS MUST hit its Pluto aim point within a minute of its target time and with an accuracy of 900 miles.

The first and foremost objective of the Jupiter flyby is to thread the orbital needle and place New Horizons at the Pluto aim point February 28, 2007. That point



Closest approach:	February 28, 2007
Distance:	1.4 million miles (2.3 million km)
Average speed:	40,500 mph (65,000 km/h)

NEW HORIZONS zips through Jupiter's system as February draws to a close. Spacecraft and satellite positions are shown at closest approach. Colored arrows indicate motion over 10 hours. *ASTRONOMY:* KELLIE JAEGER

lies 1.4 million miles (2.3 million kilometers) to Jupiter's right as we see it from Earth. This is about 10 times farther than Voyager 1's 1980 flyby, but more than 3 times closer than Cassini managed in December 2000. At closest approach, New Horizons will see Jupiter some 3.5° across in the sky — it would take more than 150 LORRI imaging frames to cover the planet in full.

New Horizons must hit its Pluto aim point within about a minute of its target time and with an accuracy of 900 miles (1,500 km). Missing either requirement would be costly, forcing the craft to use most of its precious fuel after the Jupiter encounter to trim its Pluto trajectory.

Our second goal at Jupiter is simple: Put New Horizons and its instrument payload through their paces, shaking out bugs or unexpected behaviors at Jupiter, rather than at Pluto. We want to learn as much as possible about our spacecraft at Jupiter so we learn only about Pluto at Pluto. After all, the Pluto system encounter in 2015 is a once-in-a-lifetime opportunity.

So at Jupiter, we plan to track and image multiple moving targets, run multiple instruments at the same time, fill the solid-state memory with even more data than we'll collect at Pluto, practice optical navigation, and much more. Exercising the spacecraft at this "test" flyby reduces the risk we'll miss observations at Pluto and its moons. We'll calibrate our remote-sensing instruments using Jupiter and its Galilean satellites as the spacecraft flies past, and also test the instruments' abilities to conduct virtually every type of observation they will perform at Pluto.

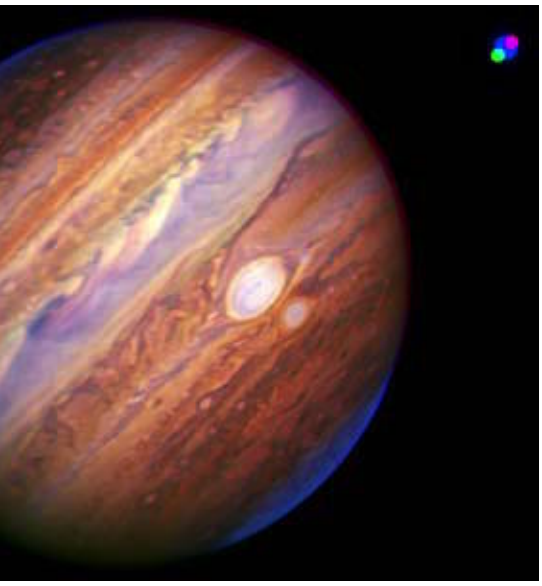
Jupiter science

New Horizons is the only spacecraft to fly by Jupiter between Cassini's late-2000 encounter and the hoped-for arrival of NASA's Juno Jupiter orbiter in 2016. And we plan to take advantage of this valuable opportunity to explore the jovian system.

New Horizons will study Jupiter's weather, with particular emphasis on cloud dynamics in and around the planet's major systems, such as the centuries-old Great Red Spot and the smaller, newly developed Red, Jr. In wavelengths from the ultraviolet through the infrared, the craft will study Jupiter's weather and aurorae — equivalent to Earth's northern lights — and the plasma torus the moon Io creates along its orbit.

New Horizons' modern instruments will map the Galilean moons more comprehensively and at higher spectral resolution than NASA's Galileo orbiter did. The spacecraft will study the distribution and shapes of Io's volcanic plumes and surface hot spots, and look for changes in Io's volcanic terrains since Galileo's investigations. New Horizons will study the thin atmospheres around each of the four big satellites. It will also study the dynamics, structure, and composition of Jupiter's tenuous ring system — even searching for the undiscovered moonlets scientists think are its source.

During 5 months, New Horizons will examine Jupiter's vast magnetosphere from stem to stern. The craft will begin sampling it from more than 200 Jupiter radii



JUPITER'S NEW RED SPOT, Red, Jr., appeared in 2006. The Keck Observatory in Hawaii captured this image July 20, when Red, Jr., passed beneath the Great Red Spot. IMKE DE PATER, MICHAEL WONG (UNIV. OF CALIFORNIA, BERKELEY); AL CONRAD (KECK OBSERVATORY), AND CHRIS GO (CEBU, PHILIPPINES)

"upstream" from the planet. How far it's able to explore downstream depends on the magnetotail's behavior in mid-2007. And, of course, the spacecraft will obtain striking images of Jupiter, its moons, and its rings during this time.

Observatories on Earth and above it — such as the Hubble Space Telescope and Chandra X-ray Observatory — are allotting hundreds of hours of coordinated imaging time in the ultraviolet, visible, infrared, and X-ray regions of the spectrum. The European Space Agency's Rosetta comet orbiter — itself completing a Mars gravity assist in February — will take part in coordinated studies of Io's torus and Jupiter's magnetotail during February and March.

Jupiter encounter

The flyby consists of an inbound monitoring phase lasting 52 days, with an intensive week around closest approach, and then outbound magnetotail exploration lasting almost 120 days. On approach, New Horizons will be closing in at an average speed of 40,500 mph (65,000 km/h).

Observatory phase, January 7 to February 23. LORRI will make three sets of jovian cloud observations. The science team will also calibrate many instruments, and conduct extensive observations of the solar wind and upstream jovian magnetosphere using SWAP and PEPSSI. Additionally, Venetia will search for dust streams from Jupiter's moon Io, and Alice will monitor emissions from Jupiter's aurorae and the Io torus that feeds them.

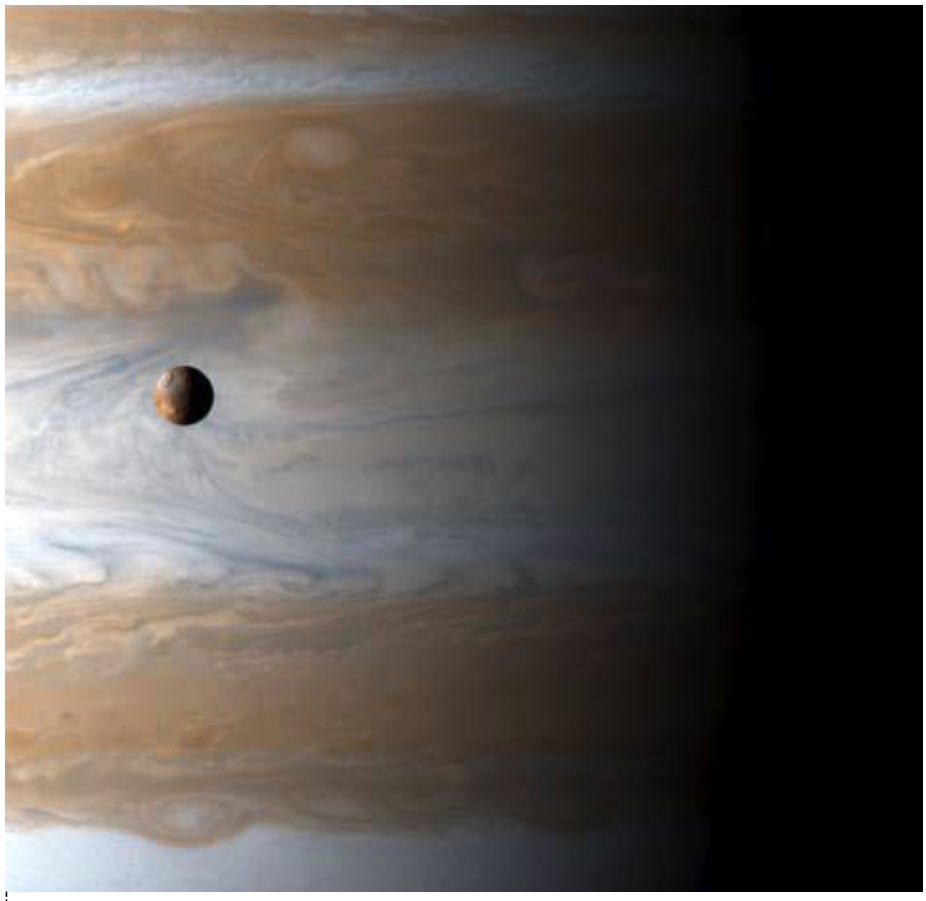
There are two opportunities during this period for course corrections to refine our inbound trajectory. Twelve days before closest approach, the spacecraft will complete transmitting all data obtained on Jupiter up to that point. This allows the team to erase the craft's solid-state memory and maximize the amount of data that can be collected around closest approach.

4 days out, February 24. New Horizons will begin watching Io for volcanic plumes. It will also map the composition of one full Ganymede hemisphere — something never done before. We'll also get an ultraviolet spectrum of Europa to study its surface ices, and use Jupiter to calibrate REX's radiometer. The craft will conduct an 8-hour sequence of jovian ring imagery to search for embedded moonlets as small as 0.6 mile (1 km) across. SWAP and PEPSSI will continue their plasma studies, while Venetia traces out the giant planet's population of dust particles.

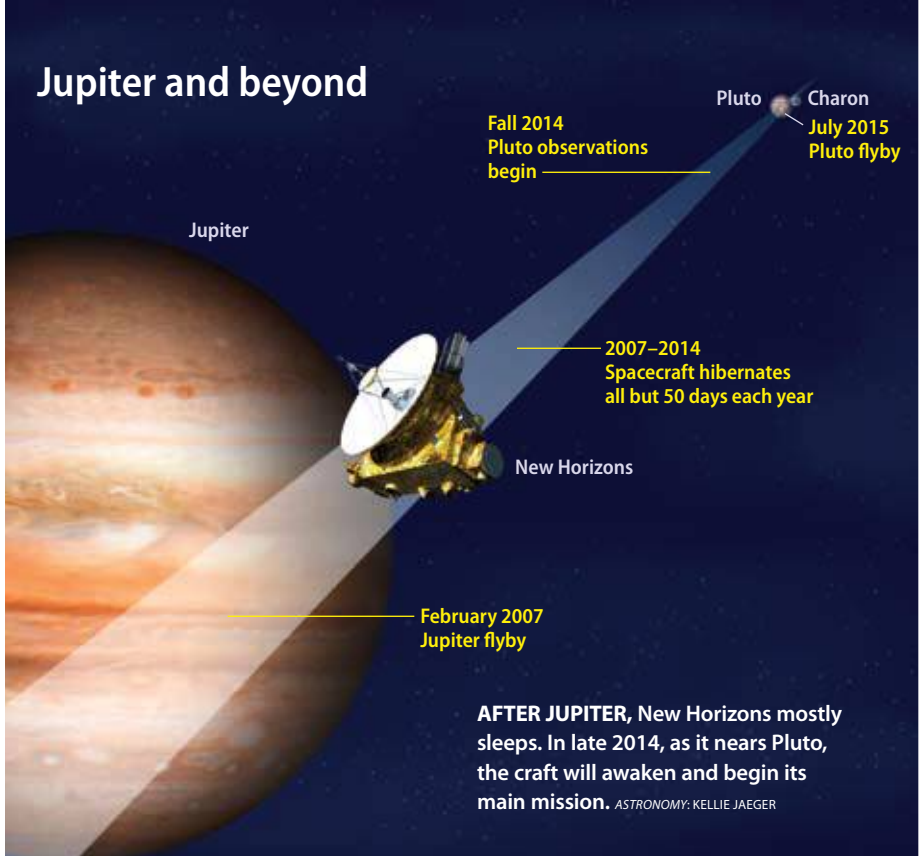
3 days out , February 25. We'll conduct two sets of Io eruption-plume monitoring with LORRI and three sets of Europa ultraviolet observations with Alice. Alice also will map emissions from the Io torus in the ultraviolet. Together, Alice and Ralph will map jovian aurorae at each of over 500 wavelengths from the ultraviolet to the infrared.

But that's not all. Plasma science with SWAP and PEPSSI will continue, while Venetia monitors the dust distribution around Jupiter. We'll also image Red, Jr., with LORRI, make composition maps of Callisto and Europa with Ralph, and search for an atmosphere on Callisto with Alice. And to top off that busy day, we'll image Europa's terminator region with LORRI to study the 3-D geology there.

26 February, 2 days out. This is Io day, complete with composition maps, surface geology mapping, and studies of the volcanic plumes and the moon's tenuous atmosphere; Ralph, LORRI, and Alice will all be



JUPITER'S CLOUDS serve as a backdrop for Io, the solar system's most volcanic body, in this Cassini image. New Horizons will get a more detailed look at Io, Europa, Ganymede, and Callisto than did either Cassini or NASA's Galileo orbiter. NASA/JPL/SSI



AFTER JUPITER, New Horizons mostly sleeps. In late 2014, as it nears Pluto, the craft will awaken and begin its main mission. *ASTRONOMY:* KELLIE JAEGER

put into service for this assault on Jupiter's "pizza" moon.

But other moons figure prominently as well. Ralph will make additional composition maps of Europa and Callisto. We'll also conduct a second search for moonlets in the jovian rings, probe the upper atmosphere by observing a stellar occultation with Alice, and study how the giant planet's storms evolve.

1 day out, February 27. Today, we bear down on the meteorology of the Great Red Spot using Ralph and LORRI. This day also marks the spacecraft's closest range to Europa and Io, so LORRI and Alice will study the moons' surfaces and atmospheres.

Closest approach, February 28. Using Ralph's imaging and composition-mapping capabilities, the science team will take advantage of the probe's close range to study the dynamics of storms and how they evolve on Jupiter. We'll also map both the Io torus with Alice and Jupiter's rings with LORRI, and obtain our best compositional maps of Callisto with Ralph. After closest approach, we'll direct Ralph and LORRI to begin nightside imaging of Io, so we can map any hot spots.

1 day out, March 1. Looking sunward toward Jupiter, New Horizons will conduct high-phase-angle studies of Jupiter, its big moons, and its rings. This backlighting highlights structures rich in fine dust.

First week outbound, March 2–7. Jupiter and its moons now appear only as thin crescents, and the spacecraft will continue high-phase-angle Ralph and LORRI observations of the system. Alice will look at the big moons in the ultraviolet and then team up with Ralph to study the planet's nightside aurorae and look for lightning. The mission team will conduct an additional REX calibration and use LORRI to study Jupiter's small moons Himalia and Elara. Magnetotail and dust studies will begin, and LORRI will obtain its last jovian images.

Magnetotail exploration, March 8 to mid-June. SWAP and PEPSSI will make round-the-clock observations of Jupiter's magnetotail at ever greater distances from the planet. Venetia will count dust-particle hits as New Horizons exits the system. LORRI, Ralph, and Alice will undergo stellar calibrations, and, if necessary, we'll trim our Pluto trajectory with a small engine burn in May. After that, our team begins testing hibernation techniques New Horizons will need for its long journey.

ON APPROACH, New Horizons closes in at an average speed of 40,500 mph (65,000 km/h).

Glen's Glide

All of the data from the New Horizons Jupiter flyby will be placed in NASA's public-domain Planetary Data System archive soon after it is received and calibrated. Transmitting this 4-gigabyte load to the ground will begin in February and continue until early July, when PEPSSI and SWAP complete their last observations. Analysis of the flyby observations will begin in earnest in spring 2007. New research based on this data should appear for the remainder of the decade.

Beginning in July 2007, New Horizons will enter hibernation, with many of its subsystems turned off and others operating only in monitoring mode. Hibernation saves money by simplifying mission operations, and it reduces wear on the spacecraft by reducing the "on time" of most of its electronics. Except for dust-particle-impact monitoring by Venetia, the instrument payload will sleep most of the time.

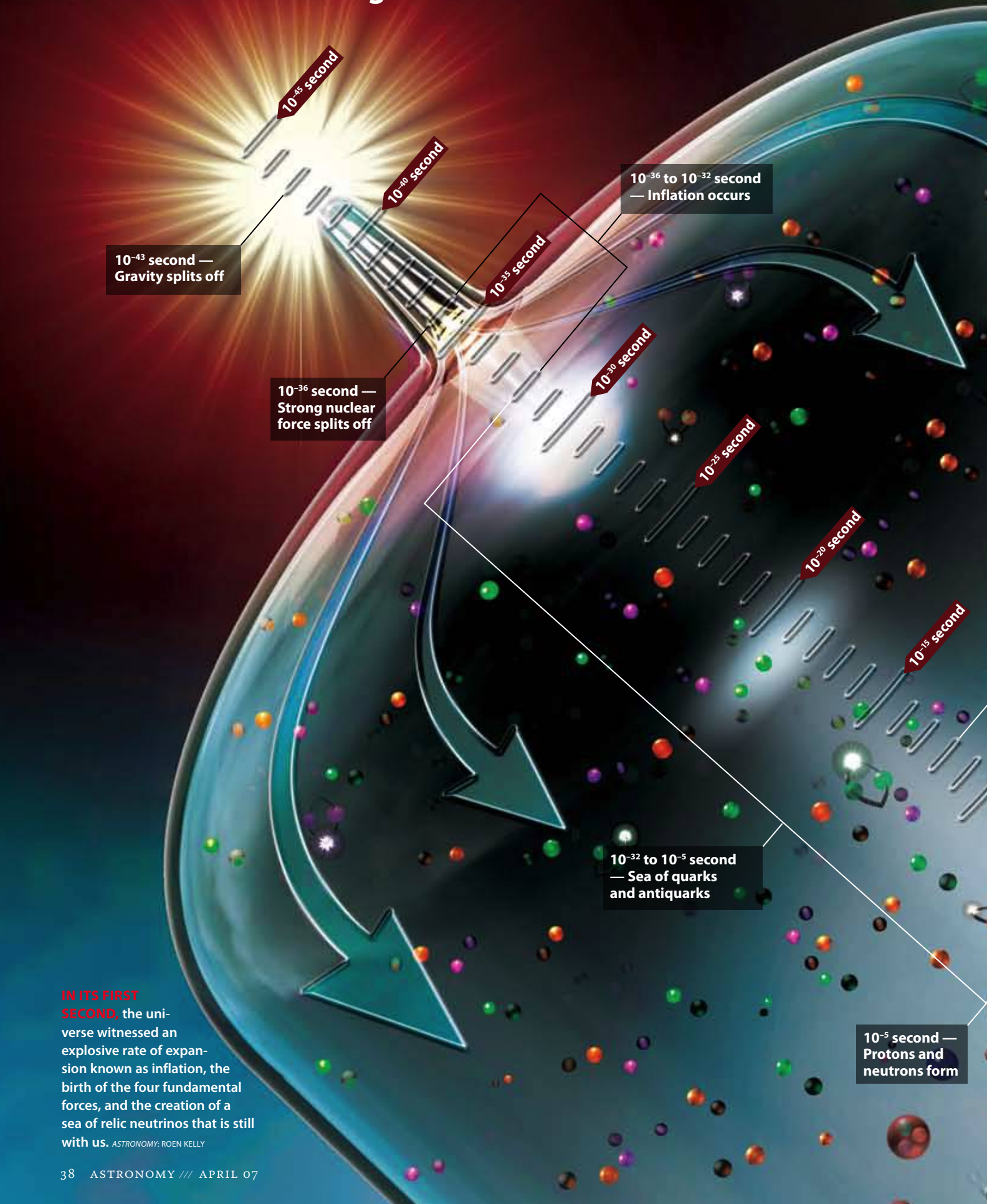
The spacecraft will remain in hibernation 10 months per year from mid-2007 until mid-2014, when the mission team starts gearing up for the Pluto encounter. During annual checkouts lasting 2 months each year, engineers will test the spacecraft and its instruments, and New Horizons will make some cruise-science observations. We may make small course corrections along the way, and there will be a pair of Pluto-encounter rehearsals in 2012 and 2014 to verify the plans are as bug free as possible.

By and large, however, it'll be a quiet 8 years. We've dubbed this period "Glen's Glide" in honor of our current project manager, Glen Fountain. He oversaw the spacecraft's construction and launch and will retire after the probe enters hibernation.

You won't hear much from New Horizons between 2008 and late 2014, but don't forget us. In early 2015, the curtain rises on the first-ever Pluto encounter. For now, though, New Horizons must first sail past Jupiter. When Pluto looms large, we'll look back fondly on our 2007 encounter with the solar system's giant.

ONLINE EXTRA See the latest images from New Horizons at www.astronomy.com/toc.

Cosmic neutrino background


10⁻⁴⁵ second
10⁻⁴⁰ second
10⁻⁴³ second — Gravity splits off
10⁻³⁶ to 10⁻³² second — Inflation occurs
10⁻³⁵ second
10⁻³⁶ second — Strong nuclear force splits off
10⁻³⁰ second
10⁻²⁵ second
10⁻²⁰ second
10⁻¹⁵ second
10⁻³² to 10⁻⁵ second — Sea of quarks and antiquarks
10⁻⁵ second — Protons and neutrons form

IN ITS FIRST SECOND, the universe witnessed an explosive rate of expansion known as inflation, the birth of the four fundamental forces, and the creation of a sea of relic neutrinos that is still with us. *ASTRONOMY:* ROEN KELLY

The Big Bang + 1 second

Scientists are trying to find the torrent of neutrinos unleashed following cosmic genesis. /// BY STEVE NADIS

10^{-12} second — Electromagnetic and weak nuclear forces split
10^{-10} second
10^{-5} second
1 second
1 second — Cosmic neutrino background forms

Astronomers who study the early universe divide into two camps: theorists and observers. Theorists routinely work on ideas like inflation, which began some 10 trillion-trillion-trillionths of a second after the Big Bang. Observers, on the other hand, hit a roadblock if they try to look back further than 380,000 years after the Big Bang — when photons of light were first set free and created the cosmic microwave background (CMB).

Yet, observers may have one path to take them back further. The Big Bang created a flood of neutrinos — subatomic particles that rarely interact with matter — that should fill the universe with an estimated 300 neutrinos per cubic centimeter, producing a background like the CMB. And those primordial, or "relic," neutrinos, date back to a mere second after the Big Bang.

No one has detected a relic neutrino, which by now would have cooled to a frosty 1.95 Kelvin, although scientists have pondered the problem for decades. The chief difficulty is that neutrinos are

Contributing editor **Steve Nadis** *is a science writer living in Cambridge, Massachusetts. He enjoys writing about cosmology and the early universe.*

NEUTRINO PRIMER

ANISOTROPY
A lack of uniformity in, say, the cosmic background, seen when looking in different directions.

COBE
The Cosmic Background Explorer, a NASA satellite launched in October 1989 that made detailed measurements of the background radiation.

COSMIC MICROWAVE BACKGROUND
The cooling afterglow of cosmic genesis, released about 380,000 years after the Big Bang at the time when matter and radiation parted ways.

COSMIC NEUTRINO BACKGROUND
The flood of neutrinos cosmologists suspect was released 1 to 2 seconds after the Big Bang.

COSMIC STRINGS
One-dimensional defects in the structure of space-time.

DOMAIN WALLS
Two-dimensional defects in the structure of space-time.

GRAND UNIFICATION THEORY (GUT)
A theory that combines electromagnetism, the strong nuclear force, and the weak nuclear force.

INFLATION
A period of rapid expansion that took place 10^{-35} second after the Big Bang.

MAGNETIC MONOPOLES
Hypothetical particles that contain only one magnetic pole.

Z-burst creation
High-energy cosmic-ray neutrino
Low-energy relic neutrino
Z-particle
Z-particle decays in 3x10^{-25} second into an average of about:
1 baryon-antibaryon pair
10 neutral pions → Decays into 20 high-energy photons
17 charged pions → Decays into electron-positron and neutrino-antineutrino pairs
Z-burst beamed toward Earth
Milky Way

ULTRAHIGH-ENERGY NEUTRINOS in cosmic rays rarely should interact with the Big Bang's relic neutrinos, creating a Z-particle and a pronounced dip in the cosmic-ray energy spectrum. *ASTRONOMY*: ROEN KELLY

THE MOON is being targeted by GLUE — the Goldstone Lunar Ultra-high energy neutrino Experiment. Scientists hope to see flashes as neutrinos explode in the lunar soil. T. A. RECTOR/I. P. DELL'ANTONIO/NOAO/AURA/NSF

THE 70-METER GOLDSTONE radio telescope looks for neutrinos crashing into the Moon. It hasn't found any. NASA/JPL

elusive by nature, even under the best circumstances, and their interactivity decreases with the square of their energy. After cooling for nearly 14 billion years, Big Bang neutrinos would pass through virtually everything without a trace. In the unlikely event that a cold neutrino did react with one of the traps astronomers have laid, the resulting signal would be "frustratingly minuscule," according to University of Hawaii physicist John Learned.

Thomas Weiler of Vanderbilt University realized in 1982 that a different approach was needed — something that went beyond conventional neutrino searches. Suppose some neutrinos are flying around at ridiculously high energies, roughly a billion times greater than our best particle accelerators can achieve. There is a special energy at which the probability of this hyper-kinetic neutrino interacting with a cold relic neutrino (or antineutrino) goes way up. This occurs at the resonant energy of the Z-particle, which is the end product of this neutrino-antineutrino collision.

THE ANITA-LITE EXPERIMENT flew over Antarctica (with Mount Erebus in the background) onboard a scientific balloon in 2003. The experiment looked for high-energy neutrino interactions with the ice. It came up dry. NASA

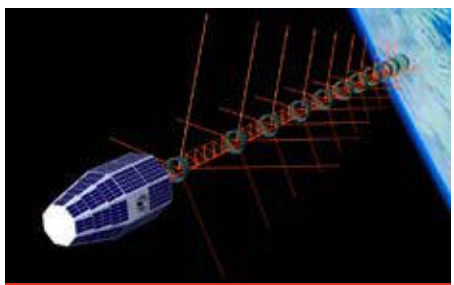
To make a Z-particle, the fast-moving neutrino would need some 10^{22} to 10^{23} electron volts (eV) of energy before slamming into its relatively inert counterpart. Anyone lucky enough to witness lots of these events would notice a dip at the Z resonance level — the energy at which the Z-particle is produced. Observing such a "Z-dip," as Weiler calls it, would confirm a cosmic neutrino background that parallels the CMB — and predates it by 380,000 years.

But the technique would yield another important benefit: Physicists could calculate the neutrino mass, because its mass is dictated by the Z resonance energy (already firmly established) and by the measured absorption energy. With this new data, physicists could, in principle, calculate the masses of the three known neutrino types — electron, muon, and tau — by identifying three separate dips.

In this way, Weiler says, we could compute the neutrino spectrum, just as investigators determine atomic spectra by shining a light on atoms and seeing dark lines at wavelengths where electrons absorb energy. Z-particles decay in a fraction of a second to make new forms of cosmic rays — protons, neutrons, and pions — that decay, in turn, to make gamma rays and neutrinos. The hope is that Earth-based observatories might pick up some of these "Z-bursts" if they originate relatively nearby.

Weiler knew from the onset that two incredible things had to happen for his scheme to work. The first requirement, that neutrinos have mass, has been borne out in experiments since his original paper was published. The second requirement, that neutrinos are somehow accelerated to tremendous energies, is contingent on as-yet-unobserved physics. Researchers have proposed two sources for ultrahigh-energy neutrinos: The first is the decay of so-called topological defects — hypothetical entities, such as cosmic strings, domain walls, and magnetic monopoles, that are like defects seen in ice and other crystals, packing lots of energy into a small space. The second possibility is the decay of heavy (and still theoretical) particles created when the universe was ultrahot.

The requirement for exotic sources, whose existence has not been verified, makes the proposition a long shot, Weiler concedes. No cosmic rays have ever been detected with energies much above 10^{20} eV,



THE FORTE (Fast On-orbit Recording of Transient Events) satellite observed Greenland in the late 1990s. It looked for lightning bolts in the ice cap created by the impact of a high-energy neutrino. It had no success. LOS ALAMOS/SANDIA/DOE

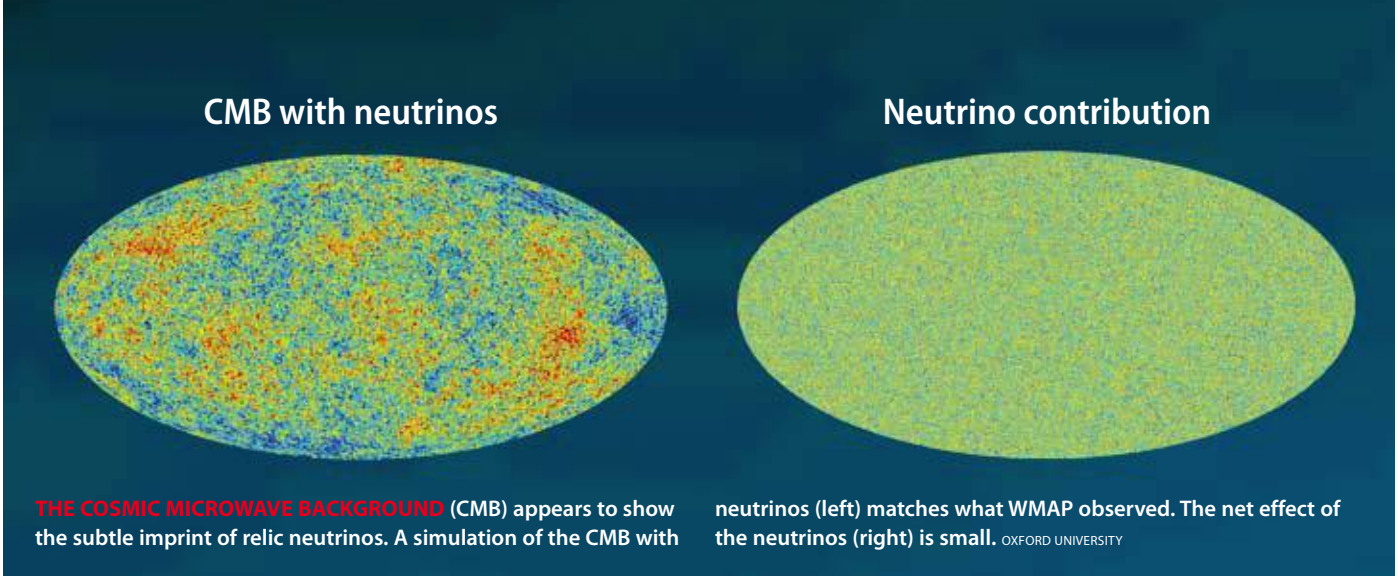
yet he's speculating about particles accelerated to energies 100 to 1,000 times greater. A new generation of neutrino and cosmic-ray detectors will be needed to confirm this conjecture, along with considerable luck.

Yet the payoff would be great. The CMB offers a glimpse of the universe when it was 380,000 years old. That's when the Big Bang photons decoupled from what had been an ionized plasma and started streaming freely. Neutrinos, which interact much more weakly than photons, decoupled from matter and radiation when the universe was just *a second or two old*. "The neutrino background would enable us to look much farther back than the CMB, offering a direct probe of the universe 1 second after the Big Bang," says Andreas Ringwald, a physicist at DESY in Hamburg, Germany.

Fluctuations in the neutrino background, formed when the universe was much smaller and denser, would be on correspondingly smaller scales than the fluctuations observed in the CMB. This would afford scientists new insights on inflation and the initial conditions that led to structure formation. Relic neutrinos are also thought to have played vital roles in nucleosynthesis and the universe's general evolution. "Learning about the physics of the universe at 1 second," says Princeton University's David Spergel, "could tell us about the strength of gravity, for example, while placing interesting constraints on the number of particles created."

The contribution to fundamental physics could be immense, claims MIT cosmologist Max Tegmark. "Information about the number of neutrinos and their masses is the final frontier of the standard model of physics. It's the big unknown — the one thing that hasn't been well measured."

"The cosmic neutrino background is a profound prediction of Big Bang theory and a very frustrating one," adds University of Hawaii physicist Peter Gorham. "It's like nature's joke on us: Here's something that must exist but you may never get to see it." On the other hand, Gorham admits, "There's no physical reason why there shouldn't be ultrahigh-energy particles, so it makes sense to look."



THE COSMIC MICROWAVE BACKGROUND (CMB) appears to show the subtle imprint of relic neutrinos. A simulation of the CMB with neutrinos (left) matches what WMAP observed. The net effect of the neutrinos (right) is small. OXFORD UNIVERSITY

He has, in fact, looked for these particles in what might seem to be the unlikeliest places: the Moon, Greenland, and Antarctica. In 2003, Gorham and his colleagues reported on the Goldstone Lunar Ultra-high energy neutrino Experiment (GLUE), which trained the Goldstone radio telescope in California on the Moon to look for explosions resulting from super-energetic neutrinos (about 10^{21} eV) slamming into it. Such a collision would release an enormous amount of energy in the form of relativistic electrons that would, in turn, create a flash of light. "The burst would be so intense that for 1 nanosecond, it would be brighter than the brightest quasar," explains UCLA physicist David Saltzberg, the project's lead researcher. But nothing like this was seen.

Gorham and other researchers looked for the effects of an ultrahigh-energy neutrino shower on the Greenland icecap, drawing on data collected by the FORTE (Fast On-orbit Recording of Transient Events) satellite from 1997 to 1999. An impact of this sort would have created a 10-meter-long lightning bolt inside the ice and an attendant radio pulse. But again, the team failed to identify such an event.

A 2004 balloon experiment over Antarctica called ANITA-LITE — a prototype of the more ambitious ANITA experiment that lifted off in December 2006 — also came up dry.

The three experiments, Gorham contends, rule out supercharged neutrinos as the main source of the most energetic cosmic rays. In the 1990s, Weiler had proposed that collisions between neutrinos and anti-neutrinos in our galaxy's halo would cause Z-bursts that could unleash the highest-energy cosmic rays ever detected on Earth. The origin of these cosmic rays remains one of the great mysteries of science, because ordinary cosmic rays can't travel very far without losing energy through interactions with CMB photons.

Weiler proposed that neutrinos could travel unfettered across the universe, creating these cosmic rays relatively nearby through the Z-burst mechanism. "But our results show there would not be a high enough flux of ultrahigh-energy neutrinos to make those cosmic rays," Gorham says.

PLANCK, a spacecraft scheduled for launch in 2008, will examine the cosmic microwave background in unprecedented detail. It seeks further evidence of the neutrino background. ESA

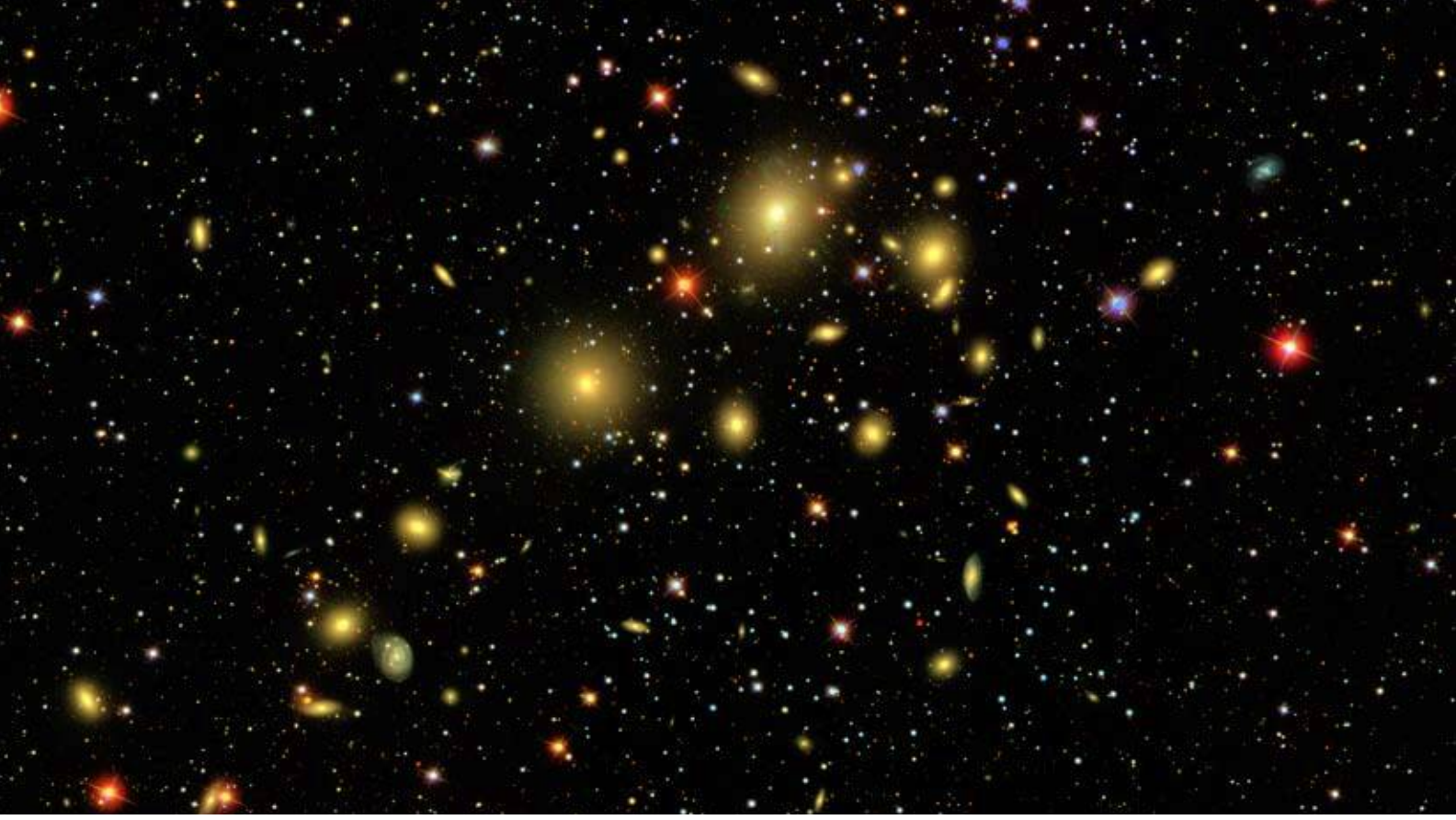
"Of course, we have not ruled out the Z-burst process itself, which might still be the best way of directly observing the cosmic neutrino background."

"While Tom Weiler's Z-burst idea is very cool, we don't know whether neutrinos get accelerated to high enough energies to make it happen," comments FermiLab astrophysicist Scott Dodelson. Fortunately, he says, there are indirect ways of studying relic neutrinos — an approach he compares to "seeing how the needle disturbs the haystack, without seeing the needle itself."

The idea is to look for the imprint of the neutrino background on the CMB, on galaxy distribution (as seen, for instance, by the Sloan Digital Sky Survey), and on the more general distribution of mass revealed by gravitational-lensing experiments. "The CMB is like money in the bank," Dodelson says. "We've done these experiments for more than a decade, and they've always delivered more than expected. Those studies, combined with galaxy surveys and lensing experiments, offer a powerful suite of techniques and the surest way of getting at the neutrino background."

Drawing on the latest WMAP findings (released in March 2006) and on large-scale structure and supernova data, Steen Hannestad, a physicist at the University of Aarhus in Denmark, claims to have seen the imprint of relic neutrinos on the CMB with better than 99.99-percent confidence. The effect is subtle, Hannestad explains, "But if the [relic] neutrinos weren't there, you'd see a completely different temperature anisotropy pattern in the CMB." Because neutrinos comprised about 40 percent of the energy density in the early universe — putting them almost on a par with photons — they contributed to the expansion of the universe. However, they did not make a comparable contribution to structure formation, which has a pronounced bearing on the temperature pattern observed in the microwave background.

Although it's an indirect detection, Hannestad says, "We now know the cosmic neutrino background is there." Tegmark shares this optimistic assessment, but Spergel is more cautious, calling the evidence



THE PERSEUS GALAXY CLUSTER is a rich collection of galaxies imaged by the Sloan Digital Sky Survey. Astronomers who map the distribution of galaxies in the universe expect to see the imprint of the cosmic neutrino background. ROBERT LUPTON AND THE SDSS CONSORTIUM

suggestive. "If the neutrino background is really there, we'll soon have very strong evidence," says Spergel.

In a 2005 paper published in *Physical Review Letters*, Roberta Trotta of Oxford University and Alessandro Melchiorri of the University of Rome carried the analysis a step further. "Not only can we detect the sea of [Big Bang] neutrinos, we can also detect the fluctuations, or wiggles, on top of that sea," Trotta says. These neutrino anisotropies have a gravitational effect on the CMB, smoothing out the clumpiness of the early universe on small scales by streaming out of dense regions at essentially the speed of light. "The cosmic neutrino background affects the onset of gravitational collapse," he adds. "If there were no neutrinos, or fewer neutrinos, star formation and galaxy formation would start earlier."

Trotta and Melchiorri ran computer simulations in the absence of neutrino anisotropies and compared the results to actual data from WMAP and the Sloan Survey. Their analysis affirmed the presence of the neutrino anisotropies at the 95-percent confidence level. The latest WMAP findings could boost the reliability to better than 99 percent. As more data come in from WMAP and its successor, Planck, "We hope to learn more about the neutrino wiggles — not just confirming that the wiggles exist but also determining their structure and distribution," Trotta says. "We're really just at the beginning."

Tegmark expects to see rapid progress on this front. By way of comparison, he says, people started looking for fluctuations in the CMB soon after it was discovered in 1963. "But zero progress was made toward a deeper understanding of theory until 1992, when the COBE results were announced," Tegmark says. "It's the same with the neutrino background: Now that the sensitivity has reached the point where we can learn interesting things about it, we'll learn rapidly."

Weiler is glad to see advances in indirect measurements, but he still believes it's important to get direct observations "to make sure what we're seeing really is the neutrino background and not the decay products of relic neutrinos." FermiLab's Dodelson, for instance, has proposed a "neutrinoless universe" scenario in which relic neutrinos annihilated themselves some 10,000 years after the Big Bang, leaving behind a background of other particles. The search for ultrahigh-energy neutrinos now awaits experiments that rely on bigger detector volumes like the full-scale ANITA.

Cosmic neutrino physics may eventually reach the required level of precision, says Ringwald. "It took decades to establish reliable sources of [10^{12} eV] gamma rays, but now there are dozens of known sources. The same could happen with cosmic neutrinos."

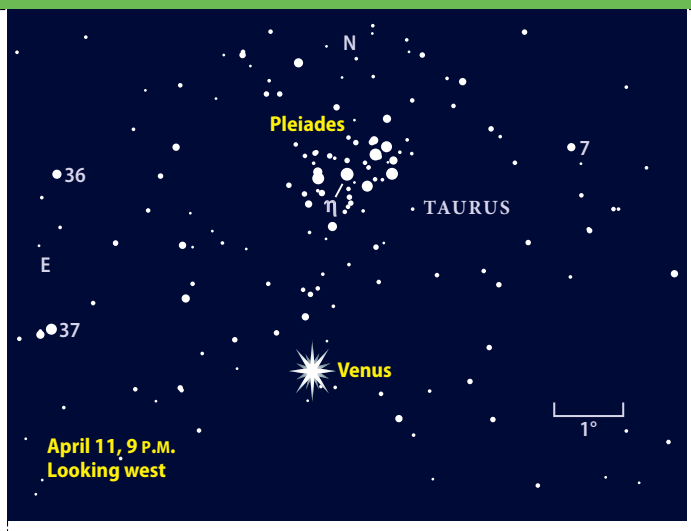
Confirmation of Weiler's Z-dip and Z-burst hypothesis would have several profound ramifications: First would be the clear-cut detection of the cosmic neutrino background. Second would be a determination of the neutrino mass. Third would be the observation of physics at the grand unification theory (GUT) scale, pointing to exotic GUT particles or even to more exotic cosmic strings. Each of these would be very important, warranting — in the opinion of Gorham and Dodelson — an automatic Nobel Prize.

Rather than getting carried away by dreams, Weiler is mindful of the harsh reality: Although the physics of Z-dips and Z-bursts looks robust, nature still has to cooperate by providing ultrahigh-energy neutrinos from sources that have not yet been identified — and might not even exist. "My 1982 idea may still be the best idea we have for directly detecting relic neutrinos. But 25 years have passed, and now we need an even better idea."

BY MARTIN RATCLIFFE AND ALISTER LING

APRIL 07

Venus skirts the Pleiades



ASTRONOMY: ROEN KELLY

VENUS DAZZLES next to the Pleiades open star cluster in Taurus. The planet passes 2.6° south of the cluster April 11. Check out this encounter with binoculars.

One of the sky's prettiest

sights is the blazing planet Venus floating above the horizon at dusk. This month, Venus passes south of the Pleiades, and the star cluster's diminutive sparkles make quite a sight in binoculars. Not far off, Comet 2P/Encke makes a monthlong hook through Aries and Cetus. Once Venus sets, Saturn rules the night — until Jupiter rises in the hours before dawn.

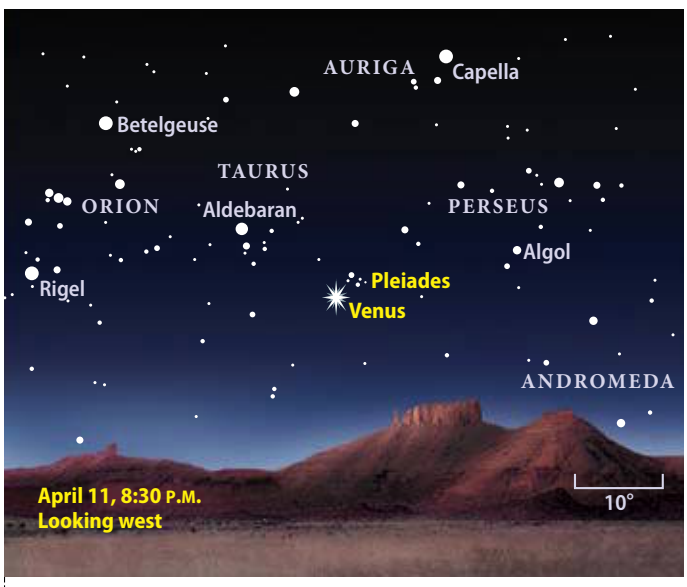
Evening planets

As soon as the Sun sets, try spotting **Venus** about 30° above the western horizon. Thirty degrees is about one-third of the way from the horizon to overhead. The planet shines at magnitude –4.0, bright enough to see in daylight.

After successfully finding the planet at dusk, now try finding Venus the next evening *before* sunset. Use a local reference, such as a tree or post, to mark its expected position. Half an hour before sunset, Venus will lie about 6° higher than its altitude at sundown.

44 Venus meets the Pleiades
49 Lyrid meteors peak
49 Meet Messala
50 When to view the planets
50 Comet Encke returns
51 Asteroid 11 Parthenope
51 Titan points to Iapetus

Visible to the naked eye
Visible with binoculars
Visible with a telescope



VENUS GLEAMS among the winter stars in the western sky after sunset. It brushes past the Pleiades April 11. ASTRONOMY: ROEN KELLY

Venus remains above the horizon for a long period because the ecliptic now cuts the horizon steeply. This places Venus in a spot that won't set until 3 hours after the Sun. Viewing Venus in a dark sky is a rare treat.

As April opens, Venus lies 12° below the famous Seven Sisters star cluster (better known as the Pleiades, and cataloged as M45). Watch Venus each night as it slides in front of the starry background, closing the apparent distance to M45.

Venus lies 2.6° south of M45's center on April 11. To enjoy the most stunning view, grab 7x50 binoculars. The dazzling cluster of jewels that make up M45 look dim with 4-carat Venus gleaming nearby.

On April 19, watch the crescent Moon position itself between Venus and the Pleiades. The Moon stands 5° from both objects — a magnificent evening display.

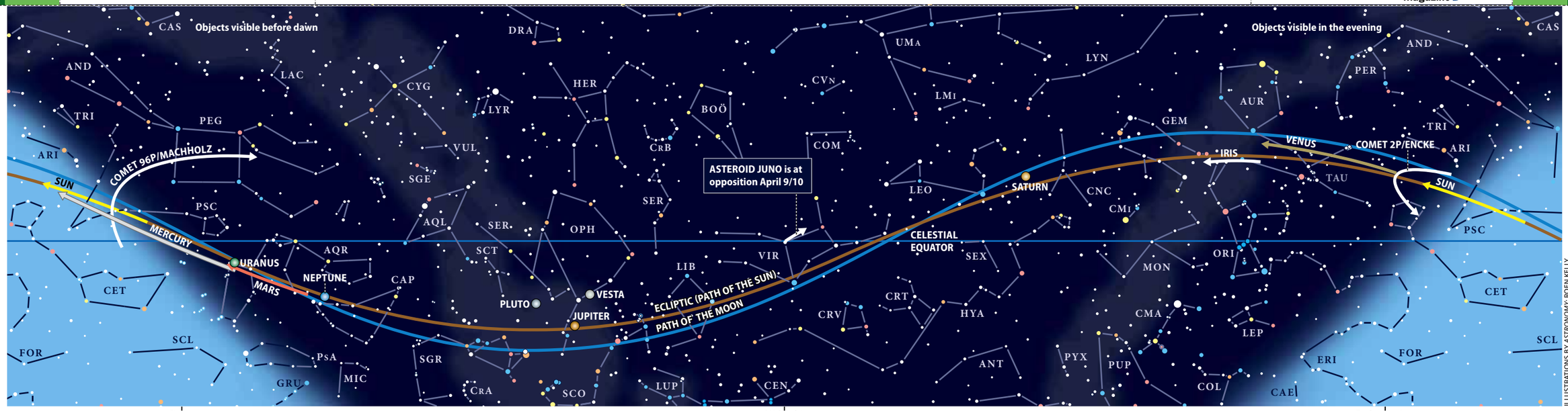
Such alignments are neither particularly rare nor scientifically significant, but they are beautiful. They also present a

— *continued on page 49*

Planets this month

This map unfolds the entire night sky from sunset (at right) until sunrise (at left). Arrows and colored dots show motions and locations of solar system objects during the month.

Astronomy magazine



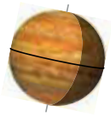
ILLUSTRATIONS BY *ASTRONOMY*: ROEN KELLY

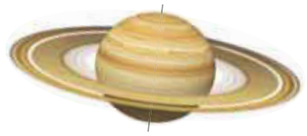
[18] [17] [16] [15] [14] [13] [12] [11] [10] [09] [08] [07] [06] [05] [04] [03] [02] [01]

[30] [29] [28] [27] [26] [25] [24] [23] [22] [21] [20] [19] [18] [17]

To locate the Moon in the sky, draw a line from the phase shown for the day straight up to the curved blue line.

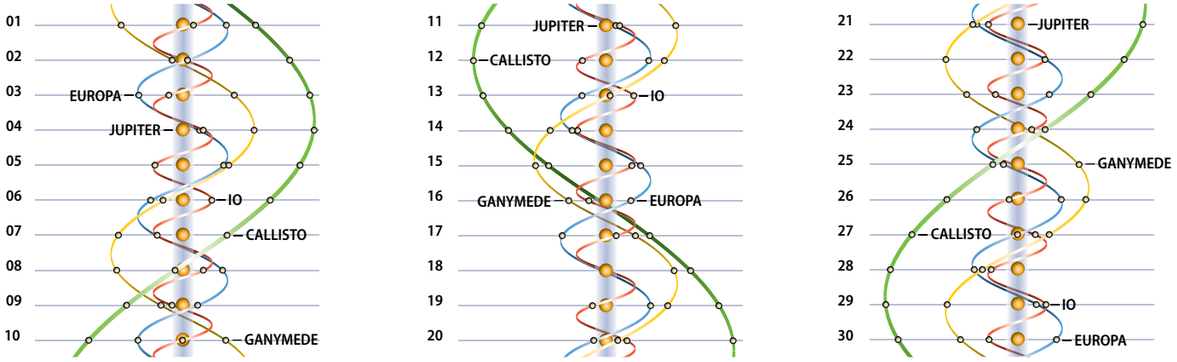
PLANETS	MERCURY	MERCURY	VENUS	MARS	JUPITER	SATURN	URANUS	NEPTUNE	PLUTO
Date	April 1	April 15	April 15	April 15	April 15	April 15	April 15	April 15	April 15
Magnitude	0.0	−0.5	−4.0	1.1	−2.4	0.3	5.9	7.9	13.9
Angular size	6.4"	5.5"	14.8"	5.0"	42.0"	19.0"	3.4"	2.2"	0.1"
Illumination	67%	83%	74%	92%	99%	100%	100%	100%	100%
Distance (AU) from Earth	1.052	1.225	1.131	1.855	4.697	8.755	20.873	30.489	30.824
Distance (AU) from Sun	0.461	0.413	0.718	1.399	5.336	9.201	20.090	30.048	31.269
Right ascension (2000.0)	23h08.4m	0h28.2m	4h03.8m	22h35.1m	17h14.8m	9h23.7m	23h12.5m	21h35.8m	17h55.1m
Declination (2000.0)	−7°56'	0°29'	22°23'	−10°22'	−22°18'	16°40'	−5°54'	−14°34'	−16°25'





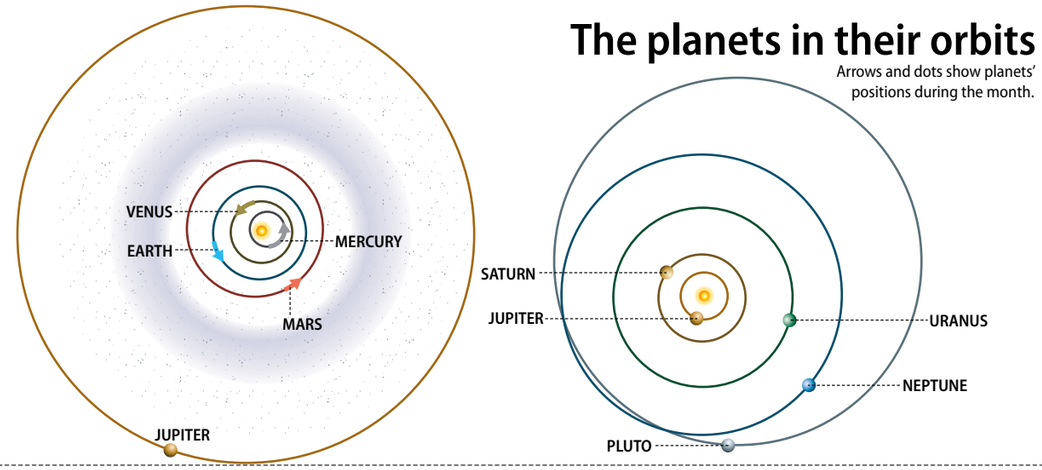
Jupiter's moons

Dots display positions of Galilean satellites at 4 A.M. EDT on date shown. South is at top to match the view through a telescope.



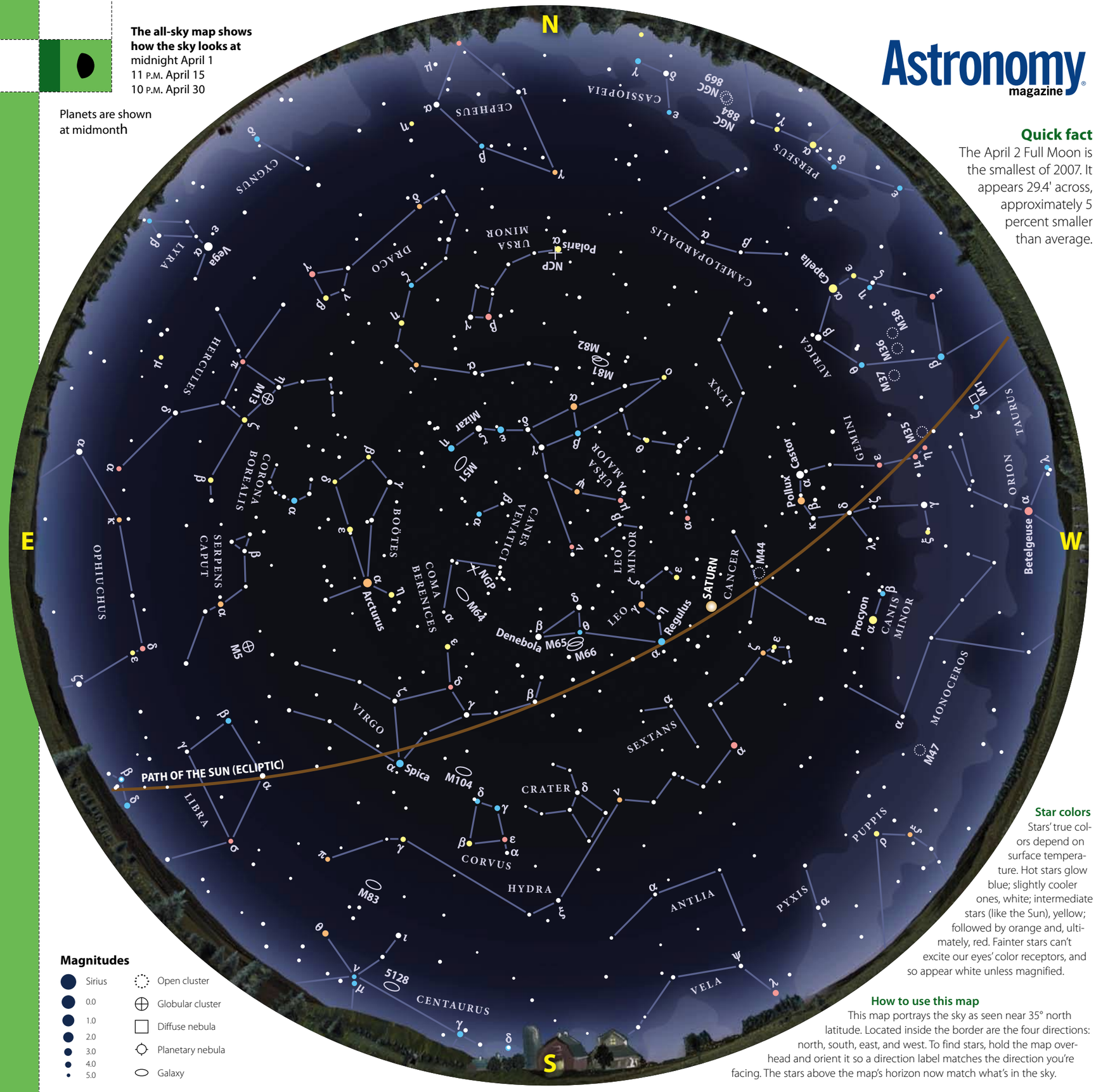
The planets in their orbits

Arrows and dots show planets' positions during the month.



The all-sky map shows how the sky looks at
midnight April 1
11 P.M. April 15
10 P.M. April 30

Planets are shown at midmonth



Magnitudes

- Sirius
- 0.0
- 1.0
- 2.0
- 3.0
- 4.0
- 5.0
- Open cluster
- Globular cluster
- Diffuse nebula
- Planetary nebula
- Galaxy

Star colors
Stars' true colors depend on surface temperature. Hot stars glow blue; slightly cooler ones, white; intermediate stars (like the Sun), yellow; followed by orange and, ultimately, red. Fainter stars can't excite our eyes' color receptors, and so appear white unless magnified.

How to use this map
This map portrays the sky as seen near 35° north latitude. Located inside the border are the four directions: north, south, east, and west. To find stars, hold the map overhead and orient it so a direction label matches the direction you're facing. The stars above the map's horizon now match what's in the sky.

Astronomy magazine

Quick fact
The April 2 Full Moon is the smallest of 2007. It appears 29.4' across, approximately 5 percent smaller than average.

april 07

SUN.	MON.	TUES.	WED.	THURS.	FRI.	SAT.
[01]	[02]	[03]	[04]	[05]	[06]	[07]
[08]	[09]	[10]	[11]	[12]	[13]	[14]
[15]	[16]	[17]	[18]	[19]	[20]	[21]
[22]	[23]	[24]	[25]	[26]	[27]	[28]
[29]	[30]					

ILLUSTRATIONS BY *ASTRONOMY*: ROEN KELLY

01 Mercury passes 1.6° south of Uranus, 3 A.M. EDT

02 Full Moon occurs at 1:15 P.M. EDT

03 The Moon is at apogee (252,481 miles from Earth), 4:38 A.M. EDT

07 The Moon passes 0.6° south of Antares, 9 A.M. EDT

08 The Moon passes 6° south of Jupiter, 5 A.M. EDT

09 Asteroid Juno is at opposition, 10 P.M. EDT

10 Last Quarter Moon occurs at 2:04 P.M. EDT

13 The Moon passes 0.5° north of Mars, 10 P.M. EDT

14 The Moon passes 1.0° north of Uranus, 4 P.M. EDT

16 The Moon passes 5° north of Mercury, 7 A.M. EDT

17 The Moon is at perigee (221,914 miles from Earth), 1:58 A.M. EDT

New Moon occurs at 7:36 A.M. EDT

20 The Moon passes 3° north of Venus, 4 A.M. EDT

21 Venus passes 7° north of Aldebaran, 8 A.M. EDT

22 Lyrid meteor shower peaks

24 First Quarter Moon occurs at 2:36 A.M. EDT

25 The Moon passes 1.1° north of Saturn, 6 A.M. EDT

26 The Moon passes 1.0° north of Regulus, 5 A.M. EDT

28 Mars passes 0.7° south of Uranus, 3 P.M. EDT

30 The Moon is at apogee (252,407 miles from Earth), 6:56 A.M. EDT

ONLINE EXTRA For definitions of terms, visit www.astronomy.com/glossary.

— *continued from page 44*

great opportunity to try astronomical photography.

Viewing Venus through a telescope allows you to follow its changing phases. Venus' orbital path swings the planet east from around the Sun's far side. Once Venus reaches its greatest angle east of our star, the planet hooks west and passes almost directly between it and Earth. As Venus doubles back, its disk changes from a nearly full phase to a slender crescent over several months.

During April, observers will see the planet's illuminated percentage shrink from a gibbous phase of 78 percent to 68 percent. Careful observers may notice the planet's disk grows in size, too. This is a result of Venus' shrinking distance to Earth. The disk spans 14" April 1 and grows to 16" by April 30. At month's end, Venus lies 94.8 million miles away — slightly farther than Earth's average distance from the Sun.

While dazzling Venus beckons, another solar system jewel lies high in the southern sky. **Saturn** glows at the unassuming magnitude of 0.3. Lying nearly 12° to the right of Regulus, Leo's brightest star, pale Saturn gives no hint of its underlying beauty. But slew a telescope toward it, and you'll be rewarded with an otherworldly sight — the orb of Saturn girdled by its spectacular ring system. Even a 60mm telescope can show Saturn's rings.

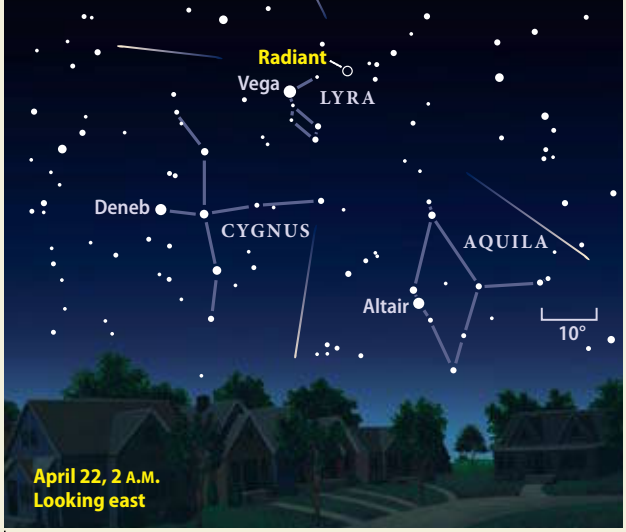
Casual viewing shows there's more than one ring, and each glows with a different brilliance. Astronomers label the rings A, B, and C. The B ring is the brightest. A marks the rings' outer visible edge in most scopes, and it's slightly fainter than the B ring. The C, or Crepe ring, is the dimmest. It's so thin, the planet's disk shines right through it.

At month's end, Saturn's distance from Earth tops 9 astronomical units — 837 million miles. The planet's disk shrinks to an apparent size of 18". The rings are shrinking, too, as Saturn gradually tilts away from Earth. When they angle edge-on to us in 2009, these thin rings will be all but invisible.

This month, though, Saturn's axial tilt not only gives us a good glimpse of the rings, but of Saturn's south polar region as well. Can you spot the slightly darker clouds that make up Saturn's polar hood?

There are few other features to see in Saturn's atmosphere.

Martin Ratcliffe *is the former president of the International Planetarium Society.* **Alister Ling** *is a meteorologist for Environment Canada.*



ASTRONOMY: ROEN KELLY

METEOR INTERMISSION ends with the Lyrid meteor shower, which peaks April 22. After midnight, as many as 20 meteors may be visible each hour.

APRIL SHOWER BRINGS METEOR TRAILS

Spring's temperate observing weather comes just in time for April's Lyrid meteor shower. This is the first shower since January's Quadrantids.

The Lyrid shower produces meteors from April 16 to 25 and peaks with about 20 meteors per hour April 22. With the Moon's first-quarter phase April 24, this year's prospects are good.

The shower radiant — in the constellation Lyra — rises by midnight, local daylight time, just as the Moon dips below the western horizon. The best rates occur a few hours before dawn, when Lyra rides high in the sky.

Lyrid meteors are fast and average as bright as the Big Dipper's stars. The particles we see as meteors originated from Comet Thatcher (C/1861 G1). This shower occasionally displays outbursts, with triple its usual rate.

MEET MESSALA

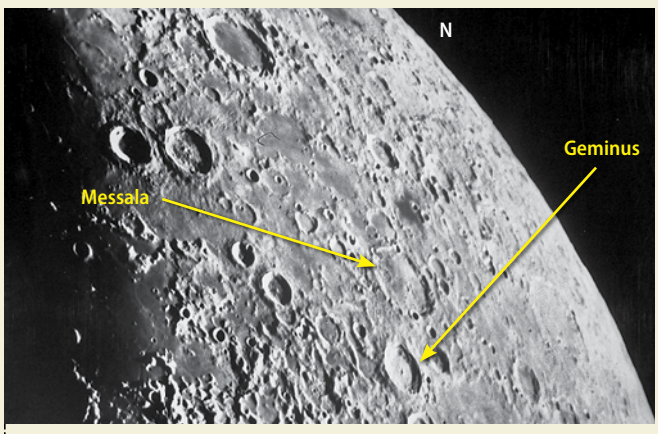
Many interesting features lie near Mare Crisium on the Moon's eastern limb. Among the large craters north of Mare Crisium is a faded one named Messala. Messala Crater's northern walls are so battered they've almost disappeared.

Debris thrown out by more recent impacts produced secondary craters that puncture Messala's rim. The most prominent, the 11-mile-wide Messala B, lies on the south rim. Messala J, in the north, seems to merge with another ancient crater, Schumacher.

Locate Messala by first finding Cleomedes, the largest crater just beyond Mare Crisium's north edge. Heading north, scan past crater Burckhardt to the prominent crater Geminus, then another crater-hop north to Messala.

Compare these two craters. Messala, 77 miles wide, holds no evidence of a central peak. But its southern walls appear terraced, and a few small craters lie just south of the crater's center.

Geminus has very few secondary craters, indicating youth. In fact, in many ways, it resembles the famous Tycho Crater.



FROM *CONSOLIDATED LUNAR ATLAS* (UA/LPL)

MESSALA is old, battered, and pockmarked with secondary impacts. Nearby Geminus, on the other hand, seems to be a more recent formation.

/// WHEN TO VIEW THE PLANETS

EVENING SKY	MIDNIGHT	MORNING SKY
Venus (west)	Saturn (west)	Mercury (east)
Saturn (south)	Jupiter (southeast)	Mars (southeast)
		Jupiter (south)

Perhaps the equatorial belt, usually its most prominent feature, will be on view. However, storms can stir up deep clouds, which appear as large white spots easily visible from Earth. Keep an eye out for such events.

While Saturn makes excellent viewing, regular changes on the planet are tough to spot. Not so with the moons. Iapetus is a favorite because its dual personality creates a significant change in brightness as it moves from one side of the planet to the other.

This month, Iapetus lies at the brighter half of its orbit. The moon shines at magnitude 10.1 April 13, which is when Iapetus reaches greatest western elongation. Follow the plane of Saturn's equator 9' west to find the dim moon; watch for other stars of similar brightness lying within the same field of view.

Saturn's other visible satellites lie much closer to the planet. For example, when Titan reaches its greatest western elongation, it lies a mere 3' away from Saturn, one-third Iapetus' distance.

On April 12, let Titan be your guide to Iapetus. Both moons are near their greatest western elongations. Titan is easy to spot because it shines brightly, at magnitude 8.4. That night, locate Titan, then scan west about 3 times Titan's apparent distance to Saturn. There, you'll find dimly glowing Iapetus.

Titan orbits Saturn every 16 days. It passes due north of the planet April 9 and 24, and due south April 16.

On April 24, look for Tethys, Dione, and Rhea in a line on Saturn's eastern side. These are Saturn's brightest moons after

ENCKE SWINGS 'ROUND THE SUN

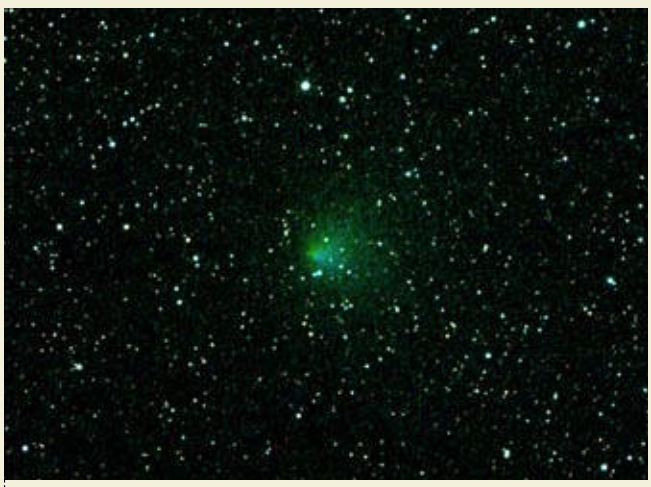
Comet 2P/Encke was the second comet (after 1P/Halley) to be recognized as a periodic visitor to the inner solar system. Encke has the shortest orbital period for a comet.

It rounds the Sun every 3.3 years. In fact, this is Encke's 61st observed apparition since French astronomer Pierre Méchain (1744–1804) discovered the comet in 1786. But while Méchain found it, German astronomer Johann Franz Encke was, in 1819, the first to compute the comet's orbit and predict its return.

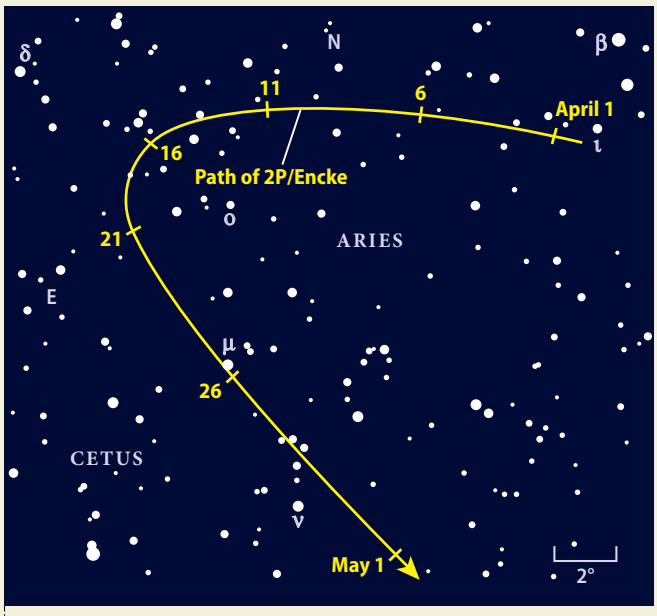
Encke likely won't brighten to better than 6th magnitude, so binoculars are the instrument of choice here. The comet hangs low in evening twilight between the Pleiades and the horizon. Encke should be fairly large and diffuse, with a short tail fanning up from the horizon. To see more delicate detail in the tail or inner coma, use a telescope, and try different magnifications.

The key to finding Comet Encke is to start an hour after sunset from a site that has an unobstructed view of the western horizon. Don't let the integrated magnitude fool you into thinking this will be an easy target from the city. Urban sky glow will make a diffuse object like a comet disappear. The real observing window opens April 4, when the bright gibbous Moon rises just as Encke sets.

But look fast. This window closes after the 15th because the comet dives toward the Sun and becomes lost in twilight.



CATCH COMET ENCKE'S 61ST OBSERVED RETURN since its discovery. Look for the comet's faint, fan-shaped tail in binoculars or a telescope during the first half of April. MIKE HOLLOWAY



ENCKE SWINGS round the Sun April 19. In the process, the comet arcs through the evening stars of Aries to those of Cetus in the morning sky. *ASTRONOMY*: ROEN KELLY

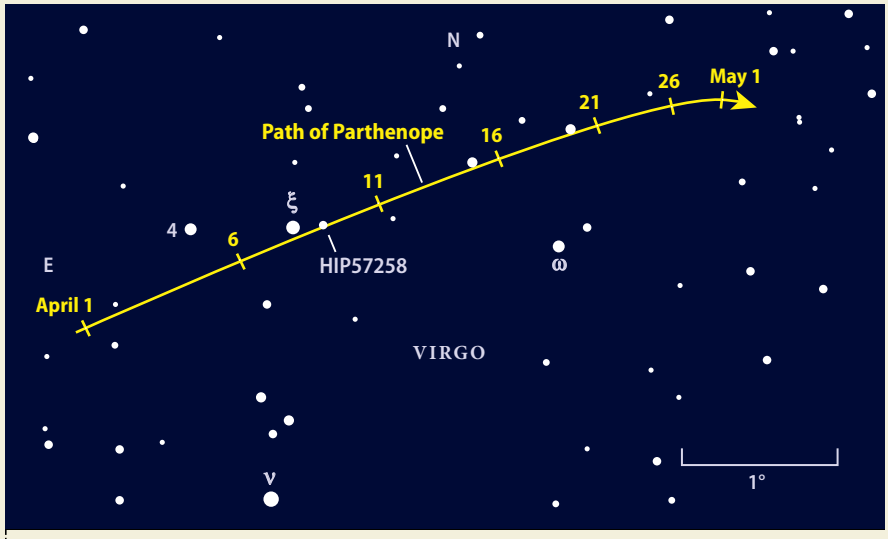
A SIREN MEETS THE MAIDEN

Except for the largest main-belt citizens, most asteroids are too small to show as disks through Earth-based telescopes. The word *asteroid* literally means "star-like," but these objects' slow nightly motions against the starry backdrop reveal the masquerade.

When an asteroid skims past a star, an observer using a small telescope can detect the rock's motion in an hour or 2. This month, asteroid 11 Parthenope swings past some bright stars in Virgo. For some observers, it will even make one star disappear.

Parthenope's name comes from one of the mythical Sirens whose song lured unwary sailors to their deaths. The asteroid's monthlong series of close stellar shaves, or appulses, are too numerous to mention here. April 8, 9, and 15 offer a sampling of rewarding telescopic views.

Parthenope shines at magnitude 10.3, so it may be tough to see the asteroid only 3' from the bright star Xi (ξ) Virginis on the 8th. On the next night, observers in just the right location will see the asteroid block out the light of 9th-magnitude HIP57258 for a few seconds. The path from which this eclipse can be seen is only 100 miles wide. For updated predictions and good observing advice, visit asteroidoccultation.com.



ASTRONOMY: ROEN KELLY

WATCH A STAR wink out as 11 Parthenope courses through Virgo. On the 9th, the asteroid briefly occults the star HIP57258.

Titan; they're usually easy to see under moderate magnification.

Our own Moon lies less than 3° west of Saturn that same night. Canadian observers in Alberta and northwestern British Columbia will see the Moon occult Saturn in the early morning hours of April 25.

By early morning April 26, the Moon will have crossed the gap between Saturn and Regulus. Observers in the western third of the continental United States will be able to watch the Moon occult Leo's brightest star. Check www.lunar-occultations.com online for details on times for your locale.

Morning planets

The solar system's largest planet, **Jupiter**, rises in the southeastern sky just as Saturn, its second-largest planet, descends in the west. By month's end, Jupiter rises in the southeast before midnight.

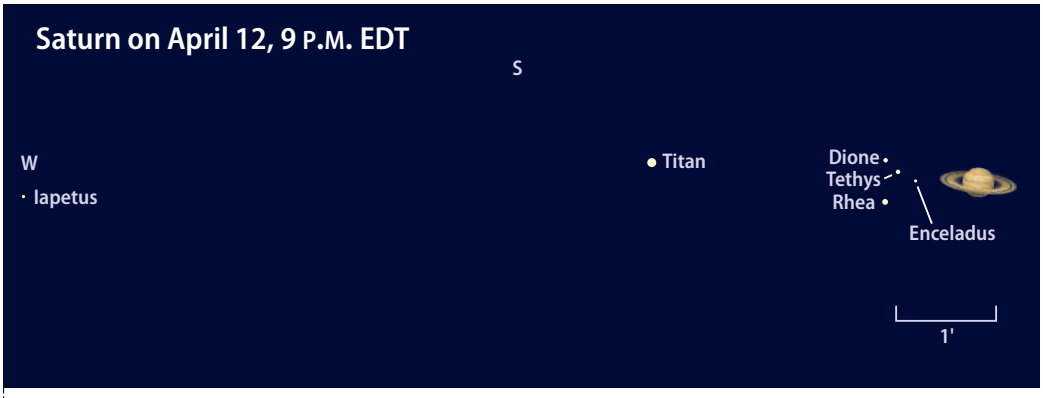
Jupiter is a favorite of planetary observers because it displays so many different features. It shows the largest fully illuminated disk of any visible planet. Even a quick glance at Jupiter reveals two dark cloud belts near the planet's equator.

Because Jupiter rotates in less than 10 hours, observers can detect atmospheric features' movement in just 15 minutes. Try watching Jupiter at the same time each night. It completes 2.4 extra spins each Earth day. So, atmospheric features just spinning into view one night will be ready to rotate out of view when observed on the following night.

Jupiter lies about 10° east of Antares among the background stars of Ophiuchus, a large-but-faint constellation north of Scorpius. Jupiter is on the fringe of richer parts of the Milky Way, so any view of the planet through a telescope will include many stars.

Jupiter's disk spans 42" — impressive given its 423-million-mile distance from us. In addition to its feature-filled disk, Jupiter also gives us the Galilean moons to study. As each moon orbits Jupiter, it occasionally passes in front of, or behind, the huge planet. This creates transits and occultations. Use the "Jupiter's moons" illustration in the magazine's pull-out center section to check their positions each night.

Mars shows little on its tiny disk when it rises in the predawn sky. It lies 165 million miles away in Aquarius. However, on April 28, Mars passes 0.7° south of **Uranus**. The pair stands at 5° altitude at 5 A.M. local time, and the star Phi Aquarii is midway between them. If your eastern horizon is perfectly clear, you might be lucky enough to catch this conjunction in binoculars.



LET SATURN'S BRIGHT moon Titan guide you to Iapetus. Far-flung Iapetus reaches its greatest angle west of Saturn April 12/13. That night, Titan, Saturn's largest satellite, lies near its greatest western angle. Scan 3 times Titan's distance from Saturn to find Iapetus. *ASTRONOMY*: ROEN KELLY

astronomics™ . . . our 28th year.

The optical center of the known Universe.™

Why buy a telescope from a website that sells pots and pans, hammocks, sunglasses, and radar detectors in addition to telescopes? If you want a real telescope, don't go to a department store. Go to a *real* telescope store.

The TMB 5.1" triplet apo is a *2007 Hot Product !*

Tired of being on a multi-year waiting list for apo optics that never come? Here's a better idea. The **TMB Optical TMB-130** 130mm f/7 triplet apo – a *Sky & Telescope Hot Product for 2007* that's available now!

The superb TMB-130 *Signature Series* refractor uses the highest grade FPL-53 ED glass in its fully multicoated air-spaced triplet lens. It yields a level of apochromatic color correction that impresses even its creator, renowned optics designer Thomas M. Back.

The TMB-130 has premium features in addition to its premium optics – like a rotating 3.5" *FeatherTouch* #3545 dual-speed rack and pinion focuser for medium format, 35mm, and CCD photography, and a collimatable temperature-compensated lens cell. It's available now and it's priced right!

TMB 130 triplet apo **$3999**

Burgess/TMB Planetary eyepieces – *more Hot Products!*

The *Hot Product* **TMB Planetary** eyepieces at $99 may shake up your beliefs about how much you have to pay for a quality eyepiece from a famous designer.

They were created by noted optics designer Thomas M. Back to complement the performance of his state-of-the-art apochromatic refractors, like the new **TMB-130**, above. When you design premium apo scopes, you design eyepieces that get the most out of them. The 2.5, 3.2, 4, 5, 6, 7, 8, and 9mm 1.25" long eye relief TMB eyepieces do just that. They'll get the most out of *your* scope, too.

$99

Your car's back seat will hold a 16" Meade LightBridge.

The **Meade LightBridge Dobsonians** – all of them named *Sky & Telescope Hot Products for 2007* – use a truss-tube design that lets you break down even the largest 16" model into a few small packages that fit comfortably into the back seat of most compact cars.

All Meade LightBridge Dobsonian reflectors have a smooth 2" machined aluminum Crayford-style focuser with a separate 1.25" eyepiece holder; a 2" 26mm QX eyepiece with a very wide 70° field of view, and an illuminated wide field non-magnifying red dot-type finder with four different reticle patterns.

Meade 16" f/4.5 LightBridge **$1999**

Steel roller bearings in the base provide smooth hitch-free azimuth motion at the touch of a finger. Altitude tension is adjustable. A battery-operated fan on the metal primary mirror cell assures fast cooling of the diffraction-limited BK7 optical glass mirror. No tools are needed to assemble and break down each Meade LightBridge in the field.

The prices below include shipping from Meade.

8" f/6 LightBridge	**$599**
10" f/5 LightBridge	**799**
12" f/5 LightBridge	**999**
16" f/4.5 LightBridge	**1999**

New lower Meade ETX prices save you $50 to $195.

The best-selling **Meade ETX-90PE** Premier Series 3.5" go-to Maksutov with UHTC optical coatings is now only $699. You save $50!

And the new $999 price for the 5" **Meade ETX-125PE** saves you $195!

It doesn't take a rocket scientist to use a Meade Premier ETX. All you have to do is tell it your zip code. *Level North Technology* automatically levels the optical tube, finds North, sets the time, and moves to two alignment stars. Center the red dot finder on those stars. Then tell your ETX which of the 30,000+ objects in its memory you want to see, and the scope takes you there *automatically.*

Each ETX comes with a tripod, red dot finder, 26mm Super Plössl eyepiece, and you can choose from a classic blue tube or one with a full-color deep space image.

Want a 6 year-old to move your telescope?

Well, maybe *not* a good idea. But the 10" pneumatic tires, pivoting front wheel, and pull handle of the **ScopeBuggy** work so well that one friend's 6 year-old moves his 14" SCT all by herself.

$265

Pentax eyepieces – performance that's worth the price.

Let's face it. Pentax eyepieces are not cheap. But many experienced astronomers feel that their premium performance is worth every penny.

XO series eyepieces yield ultra-high resolution/ultra-high contrast lunar and planetary views, particularly through a premium refractor.

The XW series has high contrast, a full 20mm of eye relief for full-field views for those of us who wear eyeglasses, and a wide 70° field that provides spectacular and sweeping deep space vistas with any scope.

2.5mm XO high performance, 44° field, 1.25"	**$289.95**
5mm XO high performance, 44° field, 1.25"	**309.95**
8-24mm XL long eye relief ED zoom, 60° to 38° field, 1.25"	**379.95**
XW wide angle long eye relief, 70° field, 1.25" – 3.5, 5, 7, 10, 14, or 20mm	**299.95**
XW wide angle long eye relief, 70° field, 2" – 30 or 40mm	**499.95**

At ***astronomics***, we specialize in telescopes and always have. Our family-owned business has been helping people choose the right telescope since 1979. We have the experience (a staff total of over *150 years* of experience

The $69.95 Astro-Tech diagonal is a *2007 Hot Product,* but truth be told, these could *all* be called hot products.

The **Astro-Tech *dielectric* 1.25" star diagonal** was named a *2007 Hot Product* by *Sky & Telescope.*

Like *all* the hot Astro-Tech diagonals, it has advanced 99% reflectivity *46-layer* dielectric coatings on its 1/10th wave BK7 optical glass substrate, plus a brass compression ring eyepiece holder that won't scratch the barrels of your costly eyepieces.

$139.95

$69.95

The 2" diagonals have either a 2" barrel for refractors or a threaded ring that connects to a Schmidt-Cassegrain rear cell, plus a separate non-marring compression ring adapter for 1.25" eyepieces.

The 2" *quartz* diagonals provide 1/10th wave peak-to-valley surface accuracy – *even after being coated* – and include a Zygo interferogram as proof of performance.

$149.95

Here are the prices of the **Astro-Tech** *dielectric* diagonals that we stock:

1.25", *a Hot Product for 2007*	**$69.95**
2" with 1.25" adapter	**139.95**
2" SCT with 1.25" adapter	**149.95**
2" quartz with 1.25" adapter	**189.95**
2" quartz SCT w/1.25" adapter	**199.95**

Coronado. Still the best buy in solar observing.

For less than cost of some premium eyepieces, the sub-Ångstrom hydrogen alpha filter in the **Coronado PST** (Personal Solar Telescope) lets you see the ever-changing drama of solar flares and prominences growing and subsiding before your eyes. The PST was a 2005 *Hot Product* and it's still a best-seller today.

$599

The PST includes a dedicated 40mm refractor, built-in solar filter, a safe built-in Sun finder, and a 20x eyepiece.

You'll find thousands of equipment reviews from other observers like you at www.cloudynights.com

Quick! What's the best-known name in eyepieces? You guessed it . . . *TeleVue.*

If you're not seeing as much through your telescope as you expected, you may not need a new scope. You may just need a new eyepiece. TeleVue eyepieces let *you* see everything your scope sees. Astronomers have sworn by no-compromiseTeleVue eyepieces since 1980. If you haven't experienced the TeleVue difference by now, isn't it time you let TeleVue open your eyes? Here are the TeleVue eyepieces we stock:

Plössl, 50° field, 1.25" – 8mm, 11mm, or 15mm	**$85.00**
20mm or 25mm Plössl, 50° field, 1.25"	**99.00**
32mm (50° field) or 40mm (43° field) Plössl, 1.25"	**118.00**
55mm Plössl, 50° field, 2"	**235.00**
8-24mm long eye relief clickstop Dioptrx zoom, 55° to 40° field, 1.25"	**240.00**
3-6mm Nagler zoom with clickstops, 50° field, 1.25"	**385.00**
2-4mm Nagler zoom with clickstops, 50° field, 1.25"	**395.00**
2.5mm Nagler Type 6, 82° field, 1.25"	**290.00**
3.5mm Nagler Type 6, 82° field, 1.25"	**290.00**
5mm Nagler Type 6, 82° field, 1.25"	**290.00**
7mm Nagler, 82° field, 1.25"	**190.00**
7mm Nagler Type 6, 82° field, 1.25"	**290.00**
9mm Nagler Type 6, 82° field, 1.25"	**290.00**
11mm Nagler Type 6, 82° field, 1.25"	**290.00**
12mm Nagler Type 4, 82° field, fits both 1.25" and 2"	**365.00**
13mm Nagler Type 6, 82° field, 1.25"	**290.00**
16mm Nagler Type 5, 82° field, 1.25"	**330.00**
17mm Nagler Type 4, 82° field, 2"	**395.00**
20mm Nagler Type 5, 82° field, 2"	**450.00**
22mm Nagler Type 4, 82° field, 2"	**480.00**
26mm Nagler Type 5, 82° field, 2"	**600.00**
31mm Nagler Type 5, 82° field, 2"	**640.00**
15mm Panoptic, 68° field, 1.25"	**215.00**
19mm Panoptic, 68° field, 1.25"	**245.00**
22mm Panoptic, 68° field, fits both 1.25" and 2"	**285.00**
24mm Panoptic, 68° field, 1.25"	**310.00**
27mm Panoptic, 68° field, 2"	**345.00**
35mm Panoptic, 68° field, 2"	**380.00**
41mm Panoptic, 68° field, 2"	**510.00**
Radian long eye relief, 60° field, 1.25" – 3, 4, 5, 6, 8, 10, 12, 14, or 18mm	**250.00**

astronomics™

Our 28th year of friendly service, reliable advice, and money-saving prices.

The optical center of the known Universe.™

680 24th Avenue SW, Norman, OK 73069

Toll-Free Telephone: **(800) 422-7876** If the toll-free telephone lines are busy: **(405) 364-0858**

Toll-free from the 50 United States and Canada.

Anyone can sell you a telescope. We'll sell you the right telescope.™

using and selling telescopes) to help *you* pick the telescope that fits your needs (and your budget). And, with our seven-figure inventory, we can usually ship you the right scope, right away, from the hundreds we stock.

"Ritchey-Chrétien-like" Meade performance . . . for only a fraction the cost of a true R-C.

Sky & Telescope said Meade's RCX400 f/8 catadioptric "does indeed perform like a Ritchey-Chrétien." And *Astronomy* said it "delivers Ritchey-Chrétien-like performance at a fraction the cost."

A **Meade LX200R** catadioptric scope uses an f/10 version of those same RCX400 f/8 optics (and a few less bells and whistles) to make "Ritchey-Chrétien-like" performance affordable for just about everyone.

Meade 8" f/10 LX200R **$2699** *freight paid*

Here are the *freight-paid* prices on the Meade LX200R f/10 go-to catadioptrics:

8" LX200R, with UHTC optics	**$2699**
10" LX200R, with UHTC optics	**3699**
12" LX200R, with UHTC optics	**4699**
14" LX200R, with UHTC optics	**6499**
16" LX200R, without mount, w/UHTC	**11,999**
16" LX200R, tripod, w/UHTC	**12,999**
16" LX200R, altaz pier, w/UHTC	**12,999**
16" LX200R, eq pier, w/UHTC	**13,299**

Why pay thousands more for the flat field of a true Ritchey-Chrétien reflector optical tube only – and still have to pay for a mount? Meade LX200R catadioptrics with "Ritchey-Chrétien-like" optics and a full go-to mount start at only $2699!

The hot Celestron Sky Scout. In stock.

One of the hardest gifts to find last December was the **Celestron SkyScout**. This *Hot Product for 2007* is still selling like there's no tomorrow, but we have it in stock today.

This GPS-based non-magnifying handheld personal planetarium locates and identifies the more than 6,000 celestial objects visible to your unaided eye. Earbuds tell you their stories, or you can read the scrolling 5-line text/graphics display. SkyScout makes the night sky as familiar to you as your own back yard. Your whole family will love it.

$399

In 1979, a coffee cost 25¢ and a Celestron 8 cost $1295. Today, $1399 buys an even better *go-to* Celestron 8.

As for the price of coffee, you practically have to mortgage your house to buy a cup at Starbucks these days.

A C8 that was state-of-the-art in 1979 would cost $3667.08 in today's inflated dollars – but it wouldn't have a *SkyAlign* go-to computer, multicoatings, a DC drive, or a Plössl eyepiece like today's $1399 **Celestron NexStar 8 SE.**

But it *would* still have Celestron's superb Schmidt-Cassegrain optics. That's one important benefit that hasn't changed over the years.

Unlike coffee and gasoline and all the other necessities of life, the cost of a Celestron has actually *deflated* over the years. You get more telescope, but you pay less money. That's because many of the features of today's **NexStar SE** scopes were unavailable at *any* price only a few short years ago. For example, the no-guesswork *SkyAlign* go-to computer – a *Sky & Telescope Hot Product for 2006* – automatically finds sky objects to make astronomy as easy as 1-2-3. And Starbright XLT multicoatings give you brighter images and higher contrast.

$799
Celestron NexStar 5SE 5" Schmidt-Cassegrain

The **Celestron NexStar SE** telescopes. Great values? *Yes!* Here are the models we stock:

NexStar 4 SE, 4" Maksutov	**$599**
NexStar 5 SE, 5" SCT	**799**
NexStar 6 SE, 6" SCT	**999**
NexStar 8 SE, 8" SCT	**1399**

From $39.95 to $399.00, Celestron has an eyepiece in your price range.

From no-nonsense $19.95 Explorascope eyepieces and $39.95 Omni Plössls to the newest premium-grade ultra-wide 82° field Axiom LX series, Celestron has eyepieces that fit your observing needs and your budget. Here are the Celestron eyepieces that we stock:

Eyepieces for tabletop Explorascope telescopes only – 6mm or 25mm	**$19.95**
Omni Plössl, 52° field, 1.25" – 4, 6, 9, 12.5, 15, 20, or 25mm	**39.95**
Omni Plössl, 1.25" – 32mm (52° field) or 40mm (43° field)	**49.95**
X-Cel ED long eye relief, 55° field, 1.25" – 2.3, 5, 8, 10, 12.5, 18, 21, or 25mm	**67.95**
8-24mm zoom, 60° to 40° field, 1.25"	**69.95**
Ultima LX, 70° field, fits both 1.25" and 2" – 5, 8, 13, or 17mm	**149.00**
Ultima LX, 70° field, 2" – 22 or 32mm	**199.00**
Axiom LX, 82° field, 1.25" – 7, 10, or 15mm	**179.00**
19mm Axiom LX, 82° field, 2"	**249.00**
23mm Axiom LX, 82° field, 2"	**299.00**
31mm Axiom LX, 82° field, 2"	**399.00**

The Telrad is more than just a red dot finder.

The **Telrad** bull's-eye non-magnifying finder is not just a finderscope. It's an astronomy icon.

$39.95 Telrad, including batteries

The Telrad seems to project 4°, 2°, and 1/2° circles of red light on the dome of the sky that make it easy to aim your telescope or to star hop from object to object. We've sold literally thousands of Telrads over the years. It's one of our best-sellers. Isn't it time you had a Telrad of your very own?

astronomics. No hard sell. No guesswork. Just honest advice, the time to make sure you get the right telescope and accessories, and a good price. Call us toll-free at (800) 422-7876 and find out for yourself.

Astro-Tech refractors. Big performance. Little price.

Premium apochromatic (color-free) optics no longer cost a king's ransom. Modern ED (Extra-low Dispersion) glass, computer-aided design, and precise CNC (computer numerical control) machining make optically excellent compact fast focal ratio refractors, such as these from **Astro-Tech**, both affordable and practical – as a first telescope, as a second scope for travel and spur-of-the-moment backyard astronomy, or as a first-rate astrograph for serious wide-field deep space photography. Just take a look:

The **Astro-Tech AT66ED**, below, has superb 66mm f/6 ED doublet optics, a rotating dual-speed Crayford focuser, a dovetail that mounts on either a photo tripod or directly on a Celestron, Meade, or Vixen equatorial mount, your choice of eight tube colors, and a hard carrying case. It's an amazing value at only $329!

$329
Astro-Tech AT66ED, in brass, chrome, black, blue, green, red, burnt orange, or white

The **Astro-Tech AT-80ED,** not shown, has 80mm f/6.9 ED doublet optics (fully multicoated, as are all Astro-Tech refractor optics), a Crayford rotating dual-speed focuser, your choice of two colors, the same dual-purpose equatorial dovetail as the AT66ED, and a hard carrying case. It's another super value at only $529.

The newest scope in the family is the **Astro-Tech AT90EDT** 90mm f/6.7 ED *triplet* apochromat below. It uses genuine FPL-53 ED glass in its three-lens optical system for superb high-contrast, color-free images (most scopes in its size and price range use less-expensive FPL-51 and are often only doublet systems). And bigger scopes are on the way!

AT90EDT **$1295**

> I bought a chrome Astro-Tech AT-66 from you a couple of weeks ago to use as a piggyback scope on a NexStar 8 GPS. I am frankly amazed by what I have seen this little scope do. I have been searching for false color, and the only instances I have seen, I am fairly certain are due to the edge of field in the eyepiece. The view easily equals the Prontos I have used, and the mechanical quality of the instrument makes them look cheap.
>
> The photos on your site have trouble showing how well the little scopes are built. I have split the double double with it at 120X (I am pretty sure it could have been done at lower power, but I wanted to get a good look at the Airy disks, which turned out not to touch each other). The fine focuser really helps on this.
>
> All in all, a superb product. It really is refreshing to see something this well thought out show up. I really am impressed. If the AT folks extended to a 102mm or 125mm size assembly, I expect they will give Televue and Takahashi a real run for their money. If they can maintain this quality level, the future should be very bright.
>
> **Customer Quote of the Month #181**

Meade. Good eyepieces. Good values.

Meade makes a wide variety of telescopes, in a wide range of prices. It makes sense that they would also make a wide variety of eyepieces to match their many scopes. And so it is. From best-selling Series 4000 Plössls starting at $49, to big 82° field Ultra-Wides priced up to $449, Meade can supply an eyepiece to match your Meade scope – or any brand of telescope! And they have specially-matched eyepiece kits that will save you big money. Here are the Meade eyepieces and eyepiece kits that we stock:

Series 4000 Super Plössl, 52° field, 1.25" – 6.4, 9.7, 12.4, 15, 20, or 26mm	**$49.00**
Series 4000 32mm (52° field) or 40mm (43° field) Super Plössl, 1.25"	**69.00**
Series 4000 56mm Super Plössl, 52° field, 2"	**99.00**
Series 4000 1.25" eyepiece and filter kit bought alone	**299.00**
6.4, 9.7, 12.4, 15, 32, and 40mm 1.25" Super Plössl eyepieces, #126 Barlow, eyepiece filter set #1 (#12, 23, 58, and 80A); #ND96 Moon filter, case	
Series 4000 kit, same as above, if bought with a Meade telescope	**199.00**
Series 4000 QX wide angle, 70° field, 1.25", 15 or 20mm	**79.00**
Series 4000 QX wide angle, 70° field, 2", 26 or 30mm	**89.00**
Series 4000 36mm QX wide angle, 70° field, 2"	**99.00**
Series 4000 8-24mm long eye relief zoom, 50° to 40° field, 1.25"	**219.95**
Series 5000 Plössl, 60° field, 1.25" – 5.5, 9, 14, or 20mm	**89.00**
Series 5000 26mm Plössl, 60° field, 1.25"	**99.00**
Series 5000 32mm Plössl, 60° field, 2"	**149.00**
Series 5000 40mm Plössl, 60° field, 2"	**199.00**
Series 5000 kit of 5.5, 14, and 20mm 1.25" Plössls; 32mm 2" Plössl; case	**349.00**
Series 5000 16mm Super Wide, 68° field, 1.25"	**179.00**
Series 5000 20mm Super Wide, 68° field, 1.25"	**199.00**
Series 5000 24mm Super Wide, 68° field, 1.25"	**249.00**
Series 5000 28mm Super Wide, 68° field, 2"	**279.00**
Series 5000 34mm Super Wide, 68° field, 2"	**299.00**
Series 5000 40mm Super Wide, 68° field, 2"	**399.00**
Series 5000 Super Wide kit of 16 & 24mm 1.25"; 34mm 2"; case	**599.00**
Series 5000 Ultra Wide, 82° field, 1.25" – 4.7, 6.7, 8.8, or 14mm	**199.00**
Series 5000 18mm Ultra Wide, 82° field, 1.25"	**279.00**
Series 5000 24mm Ultra Wide, 82° field, 2"	**399.00**
Series 5000 30mm Ultra Wide, 82° field, 2"	**449.00**
Series 5000 Ultra Wide kit of 6.7 & 18mm 1.25"; 30mm 2"; case	**749.00**

24-Hour FAX line: (405) 447-3337 Our e-mail address: questions@astronomics.com
Our award-winning Internet site: www.astronomics.com Mastercard, Visa, Discover, American Express.
PHONE HOURS: 8 to 9 CST Monday thru Friday, Saturday 12 to 5. STORE HOURS: 9 to 5 Monday thru Friday, Saturday by appointment.
U. S. sales *only* – except for Meade and Takahashi which are available for sale to Canada. Prices, special offers, and specifications are current as of 1/10/07, but are subject to change. $7.95 minimum freight. All returns less freight. Restocking fees apply to returns for credit and to merchandise returned used or damaged. **We meet or beat any advertised price.**
Price match fine print: competitor's price must be verifiable and available nationally; chain store, close-out, and going-out-of-business prices are excluded; no retroactive price matching; a package price must be from a single competitor.

Venture off the beaten path to observe twelve extragalactic gems Messier missed. /// **BY STEVE GOTTLIEB**

Explore a dozen must-see galaxies

Spice up your observing sessions by

taking a tour of a dozen often overlooked springtime galaxies. These objects are just as impressive at the eyepiece as those with a Messier designation. Galaxies appear washed out in light-polluted skies, so head out to a dark site for the best views — you won't be disappointed with what you see through your telescope.

Let's begin with the **Hotspot Galaxy** (NGC 2903), one of the brightest galaxies missed by French comet-hunter Charles Messier (1730–1817). To locate this barred spiral in the constellation Leo, point your scope at 4th-magnitude Alterf (Lambda [λ] Leonis) and then drop 1.5° south. In 2001, the Hubble Space Telescope resolved infrared hot spots in the galaxy's central region into sites of intense star formation. Because of these hot spots, astronomers classify NGC 2903 as an active starburst galaxy.

From a dark site, my 9x50 finder scope reveals a soft, elongated glow. An 8-inch scope provides an impressive view of NGC 2903, showing a bright, mottled core encased in a large oval disk.

Through my 18-inch Starmaster, the galaxy stretches across a 10' by 4' area of sky. The disk appears splotchy due to dust and HII knots, which are regions of ionized hydrogen. Two of these faint knots are symmetrically placed northeast and southwest of the core, respectively. In the 1850s, observers using Irish astronomer Lord Rosse's (1800–1867) 72-inch reflector (called the Leviathan of Parsonstown) first described these regions as "two subordinate nuclei on either side of center."

Our next target is the **Spindle Galaxy** (NGC 3115). This 9th-magnitude lenticular galaxy (it has a lens-like appearance when seen edge-on) resides in the star-poor constellation Sextans roughly 30 million light-years away. Astronomers using the Canada-France-Hawaii Telescope and Hubble measured the rotational velocity of stars near this galaxy's center and discovered the existence of a 2-billion-solar-mass black hole in NGC 3115's core.

It's surprising this galaxy escaped Messier. Even the smallest scope reveals an elongated glow tilted southwest to northeast and brightening in the center. A 6-inch scope displays this edge-on galaxy's high surface brightness and narrowing tips. Through my 18-inch scope, NGC 3115's intensely glowing core harbors a striking, nearly stellar, nucleus with tapered extensions that stretch 5.5' by 1.3'.

CHRIS SCHUR

1 THE HOTSPOT GALAXY (NGC 2903) is so named because its central region contains areas of intense star formation. Dust and HII knots cause this barred spiral's oval disk to appear splotchy. The Hotspot lies in the constellation Leo.

2 THE SPINDLE GALAXY (NGC 3115) harbors a 2-billion-solar-mass black hole at its center. We see the Spindle edge-on. This star-poor galaxy is long and has tapered ends, giving NGC 3115 its lens-like appearance. CHRIS SCHUR

ADAM BLOCK/NOAO/AURA/NSF

3 SPIRAL GALAXY NGC 3521 lies 35 million light-years away in Leo. This galaxy's bright oval core is surrounded by knotty spiral arms dotted with stars. A dark dust lane cuts across NGC 3521's western edge.

Steve Gottlieb *gave readers tips for observing exploded stars in the September 2006 issue. He observes under the skies of northern California.*

ADAM BLOCK/NOAO/AURA/NSF

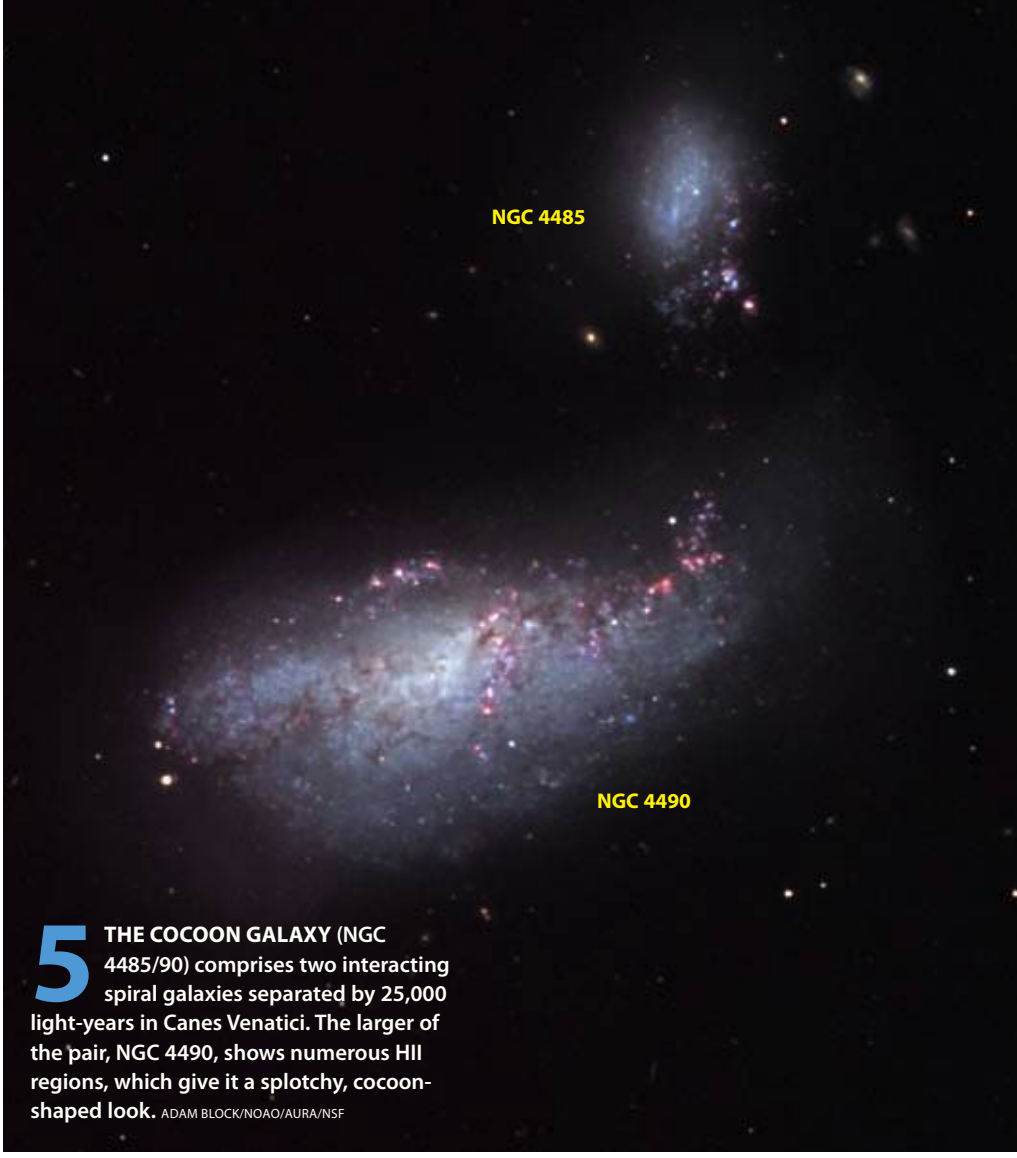
4 THE SILVER NEEDLE GALAXY (NGC 4244) takes its name from its long, slender, needle-like appearance. Located some 8 million light-years distant in the constellation Canes Venatici, the Silver Needle appears edge-on and spans 16′.

Next, let's head over to the constellation Leo and spiral galaxy **NGC 3521**. This 9th-magnitude galaxy straddles the celestial equator in southeastern Leo. Unfortunately, this galaxy often is bypassed in favor of splashier M65 and M66 to the north. Next time you're in this region, take a look at NGC 3521. Images reveal multiple knotty spiral arms and dust lanes that tightly wind down to a blazing core.

An 8-inch scope shows a bright, 5′ by 2′ oval sporting a concentrated core and a fainter halo tipped north-northwest to south-southeast. The view is impressive in my 18-inch scope at 225x — the region surrounding the small, elongated core is mottled, with hints of spiral structure, while the core brightens to a star-like nucleus. A dust lane is evident along the galaxy's west side. A dim outer portion of the disk extends beyond this dust lane.

Canes Venatici is home to the **Silver Needle Galaxy** (NGC 4244) as well as a splendid collection of four splashy Messier galaxies (M51, M63, M94, and M106). To star-hop to the Silver Needle, begin at 4th-magnitude Chara (Beta [β] Canum Venaticorum), and then slide 2.8° southwest to 5th-magnitude 6 Canum Venaticorum. Continue another 2° southwest to arrive at NGC 4244.

In a 4-inch or 6-inch scope, this ghostly sliver stretches 10′ to 12′ in length. Through my 18-inch scope, the Silver Needle pierces 16′ by 1.5′ of sky and slopes southwest to northeast. The galaxy brightens toward the center and tapers at the tips. NGC 4244's surface brightness is low, but it exhibits a grainy texture. Because this galaxy lies only 8 million light-years away, a large amateur scope reveals unresolved clumps of dust and its luminous star clouds.



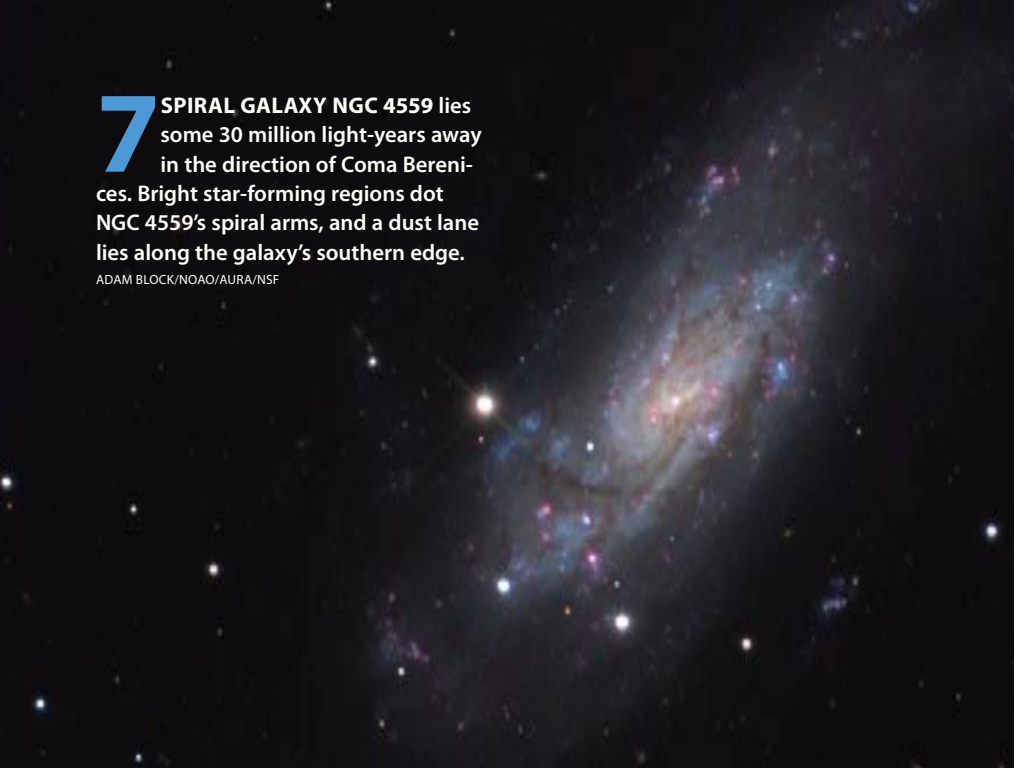
5 THE COCOON GALAXY (NGC 4485/90) comprises two interacting spiral galaxies separated by 25,000 light-years in Canes Venatici. The larger of the pair, NGC 4490, shows numerous HII regions, which give it a splotchy, cocoon-shaped look. ADAM BLOCK/NOAO/AURA/NSF

NGC 4485 and NGC 4490 form a remarkable pair of interacting galaxies known collectively as the **Cocoon Galaxy**. Find the pair 40′ northwest of Chara. Separated by 25,000 light-years, this duo now is rushing apart from an earlier encounter that disrupted the galaxies and pulled out a bridge of gas and stars linking NGC 4485 to NGC 4490's western arm.

An 8-inch scope easily shows NGC 4490 as an irregular 5′ by 2.5′ oval encasing a bright, grainy core. Its fainter companion, NGC 4485, is a small glow just 3.5′ north of the western end. Through my 18-inch scope, NGC 4490 has a mottled, splotchy appearance due to its numerous HII regions. At its western end, the galaxy is distorted into a teardrop shape with a faint extension that hooks sharply to the north toward NGC 4485.

ADAM BLOCK/NOAO/AURA/NSF

6 IRREGULAR GALAXY NGC 4449 lies in Canes Venatici. Active star formation is a hallmark of NGC 4449. This galaxy's structure and size are similar to those of the Large Magellanic Cloud, a small companion galaxy to the Milky Way.



7 SPIRAL GALAXY NGC 4559 lies some 30 million light-years away in the direction of Coma Berenices. Bright star-forming regions dot NGC 4559's spiral arms, and a dust lane lies along the galaxy's southern edge. ADAM BLOCK/NOAO/AURA/NSF

8 SPIRAL GALAXY NGC 4605 in Ursa Major is brightest at its southeastern end. It shines at 10th magnitude but has splotchy surface brightness. This dwarf galaxy is classified as an SBc/P type, meaning it is a peculiar barred spiral galaxy. PRESTON JUSTIS

Head 2.5° north-northwest of the Cocoon to catch a view of the **Magellanic Dwarf** (NGC 4449). This fascinating irregular galaxy, which resembles our galaxy's large satellites, the Magellanic Clouds, contains an asymmetric bar studded with blazing regions of star formation. A 2001 Hubble study suggests an encounter with a neighboring galaxy may have triggered the formation of several super star clusters (SSCs), which are similar to young, massive globulars.

An 8-inch scope reveals a 4' by 2' oval surrounding a well-concentrated core and patchy, knotty structures. My 18-inch scope reveals several glowing HII regions scattered over an irregular, mottled surface. The largest is a high-surface-brightness knot on the galaxy's northern edge. Glimpse fainter nebulous spots to the southeast and southwest. Directly attached to the south end of the core is another bright patch. I used 325x while searching for these extragalactic HII regions.

The next time you observe the popular edge-on showpiece called the Needle Galaxy (NGC 4565), head 2° north to a lesser-known 10th-magnitude spiral in Coma Berenices, **NGC 4559**. Images display a small central bulge embedded in filamentary spiral arms. Through a 6-inch or 8-inch scope, you'll find a 6' by 2.5' oval with modest brightening at its center.

Seen through an 18-inch scope, NGC 4559's halo extends 7' by 3'. The galaxy's structure is fascinating. Its surface brightness is irregular, with brighter and darker spots in the spiral arms. This mottling suggests dust lanes and HII regions. The southeast extension has an odd, boxy appearance and looks mottled. A trio of 12th-magnitude stars cradles this end of the galaxy.

Our next target, **NGC 4605**, is a peculiar 10th-magnitude spiral. Because of its location in Ursa Major, NGC 4605 is overshadowed by the well-known galaxies M81, M82, and M101. However, NGC 4605 is worth a visit. Through a 6-inch scope, you'll discover a 3' by 1' mottled oval sloping northwest to southeast that increases in brightness toward NGC 4605's center.

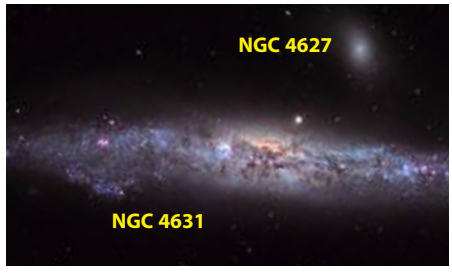
With my 18-inch scope, the galaxy increases in size to nearly 5' by 1.2' and shows hints of a tortured past. The southeast extension is clearly brighter and more tapered than the galaxy's wider northwest end and exhibits a splotchy surface brightness. A slight kink in the major axis lies near the center, and the galaxy's two ends are misaligned.

The **Whale Galaxy** (NGC 4631) is a stunning 9th-magnitude edge-on object. This high-surface-brightness spindle spans 15.5' by 2.7' and displays noticeable mottling. Dust veins meander through bright regions of active star formation, triggered by past interactions with its neighbors, NGC 4627 and NGC 4656.

Through my 18-inch scope, the Whale Galaxy extends just beyond the edges of a 14' field, gradually bulging toward the center and tapering at its western tip. The Whale's mottled surface resolves into a maze of bright and dark patches, and the galaxy's northern edge has a distinctive serrated, or scalloped, appearance. A giant HII region, as well as several smaller luminous spots, lie near NGC 4531's center, along its north side. Companion galaxy NGC 4627 hovers just 2.5' northwest of the Whale Galaxy's center.

You'll find the **Hockey-Stick Galaxy** (NGC 4656/57) a mere 0.5' southeast of NGC 4631. An earlier encounter with NGC 4631 warped the Hockey-Stick Galaxy's disk and tidally twisted its northeast end, nearly detaching a chunk of the galaxy. When William Herschel discovered this galaxy in 1786, he described it as double and mentioned that "both join and form the letter 'S.'" The nickname "Hockey Stick" refers to this galaxy's distorted shape.

A 4-inch scope reveals an elongated 6' by 1' glow that is brighter and wider on the southwest end. Ten-inch and larger scopes will show the galaxy's northeast end brightens and hooks abruptly to the east — a result of tidal distortion. A faint piece is



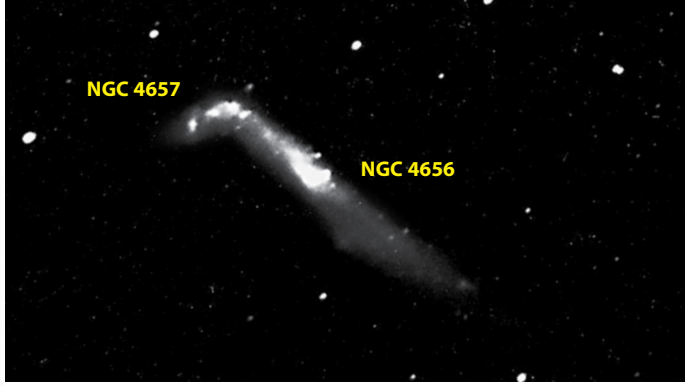
ADAM BLOCK/NOAO/AURA/NSF

9 THE WHALE GALAXY (NGC 4631) resembles the sea creature from which it takes its name. The Whale, the larger of the pair, has luminous spots along its northern edge. Seen edge-on, this spiral galaxy spans 15.5' and lies in Canes Venatici.

/// SPRINGTIME GALAXY TARGET LIST

Name	R.A.	Dec.	Con.	Mag.	Size
NGC 2903	9h32m	21°30'	Leo	9.0	12.6' by 6.0'
NGC 3115	10h05m	–07°43'	Sex	8.9	7.2' by 2.5'
NGC 3521	11h06m	–00°02'	Leo	9.0	11.0' by 5.1'
NGC 4244	12h17m	37°48'	CVn	10.4	16.6' by 1.9'
NGC 4449	12h28m	44°06'	CVn	9.6	6.2' by 4.4'
NGC 4490/85	12h31m	41°38'	CVn	9.8	2.3' by 1.6'
NGC 4559	12h36m	27°58'	Com	10.0	10.7' by 4.4'
NGC 4605	12h40m	61°37'	Uma	10.3	5.8' by 2.2'
NGC 4631	12h42m	32°32'	CVn	9.2	15.5' by 2.7'
NGC 4656/57	12h44m	32°10'	CVn	10.5	15.1' by 3.0'
NGC 5253	13h40m	–31°38'	Cen	10.4	5.0' by 1.9'
NGC 5981	15h38m	59°23'	Dra	13.2	3.0' by 0.5'
NGC 5982	15h39m	59°21'	Dra	11.1	3.0' by 3.1'
NGC 5985	15h40m	59°20'	Dra	11.1	5.5' by 3.0'

LEGEND
R.A. = right ascension in hours and minutes (2000.0) Dec. = declination in degrees and minutes (2000.0) Con. = constellation Mag. = magnitude ' = arcminutes

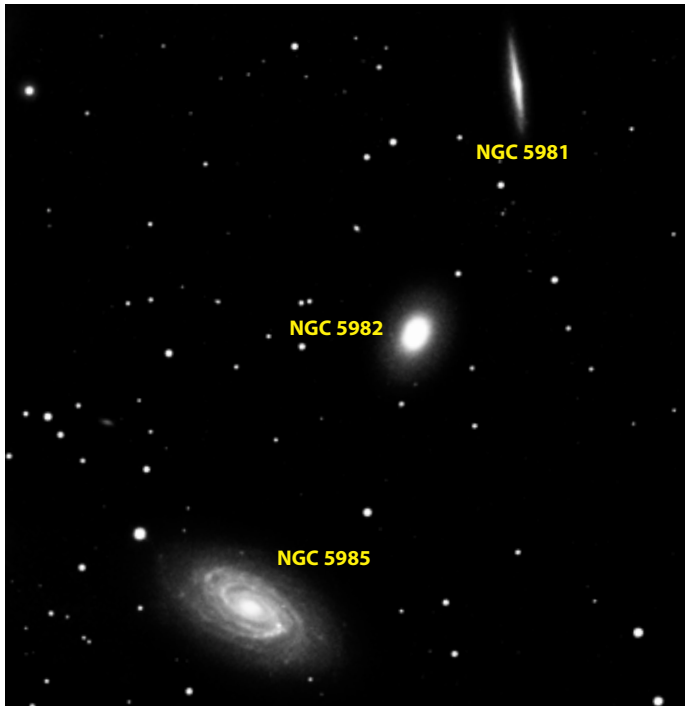


MACE HOOLEN

10 THE HOCKEY-STICK GALAXY (NGC 4656/57) in Canes Venatici is a large spiral. Twisted out of shape by neighboring galaxy NGC 4631 to the northwest (not shown), the Hockey Stick has a bright knot on its southern end and a smaller, nearly detached area on its northeastern side.

JIM BARCLAY

11 DWARF STARBURST GALAXY NGC 5253 is an amorphous oval galaxy some 12 million light-years away in Centaurus. Discovered by John Herschel in 1787, NGC 5253 has an active star-forming core packed with myriad star clusters.



ADAM BLOCK/NOAO/AURA/NSF

12 GALAXY TRIO NGC 5981, NGC 5982, and NGC 5985 offers a sampling of the three main galaxy types. The largest of the group, NGC 5985, is a face-on spiral. NGC 5982, center, is an elliptical. Long, slender NGC 5981 is an edge-on galaxy.

nearly detached at the northeast tip and appears tilted at a steep angle.

Although many observers are familiar with barred spiral M83 in Hydra, a little-known gem, **NGC 5253**, lies 1.9° south-southeast. Seen through an 8-inch scope, you'll find a prominent oval angling southwest to northeast. The concentrated core is a region of intense star formation, classifying NGC 5253 as a dwarf starburst galaxy. At roughly 12 million light-years away, it's the closest starburst galaxy to Earth.

Observing through an 18-inch scope from Australia with NGC 5253 high overhead, the galaxy extended 4' by 1' and brightened to an intense 20"-long core. I saw a bright, nearly stellar knot attached to the core's northeast edge. This may be one of many super star clusters.

For our last target, let's try a three-for-one special: **NGC 5981**, **NGC 5982**, and **NGC 5985**. Less than 2° east-northeast of 3.3-magnitude Edasich (Iota [ι] Draconis), galaxy trio NGC 5981, NGC 5982, and NGC 5985 lies strung out perfectly on a line 14' long. Better yet, they form a galaxy sampler with an edge-on, an elliptical, and a nearly face-on spiral!

An 8-inch displays elliptical galaxy NGC 5982 as a 1.2' by 1.0' oval with a small, concentrated core. About 7' east is NGC 5985, a larger, nearly face-on spiral with a lower-surface-brightness disk. Through my 18-inch scope, the disk extends 4' by 2.5' and appears mottled with strong spiral structure. NGC 5981 is a challenge for an 8- or 10-inch scope. Look 6' west of NGC 5982 for a faint, narrow splinter sloping northwest to southeast.

These often overlooked galaxies await your gaze. Pick out a few and give them a try on the next clear spring evening. Once you've gotten your fill of these springtime galaxies, visit www.astronomy.com/toc for a list of additional targets to explore.

ONLINE EXTRA To find a list of more spring galaxy targets and a Meade Autostar tour, visit www.astronomy.com/toc.

ASK ASTRO

Astronomy's editors and experts from around the globe answer your questions about the cosmos. This month: measuring a magnetar's pulse, why black holes have jets, why you see no green stars, and making sense of constellation boundaries.

MAGNETAR ENERGY OUTPUT

Q: Can a 0.2-second pulse from a magnetar put out as much energy as the Sun does in 250,000 years? — **RUSS MOBLEY,** WHITEHOUSE STATION, NEW JERSEY

A: Yes. A giant magnetar flare is incredibly bright and emits as much radiation energy as the Sun does in hundreds of thousands of years.

How is it done? Even theorists aren't sure. What scientists do know is that the energy comes from these stars' intense magnetic fields, which are trillions of times stronger than the magnetic field on Earth's surface — hence, astronomers call these objects "magnetars."

One model predicts a surface disturbance, or star quake, on a neutron star shakes its intense magnetic fields. The shaking causes the magnetic-field lines to merge and release huge amounts of energy in the process. This process is similar to what happens during a flare on the Sun, but much more energetic.

— **NEIL GEHRELS,** NASA GODDARD SPACE FLIGHT CENTER, GREENBELT, MARYLAND

BLACK-HOLE ESCAPE

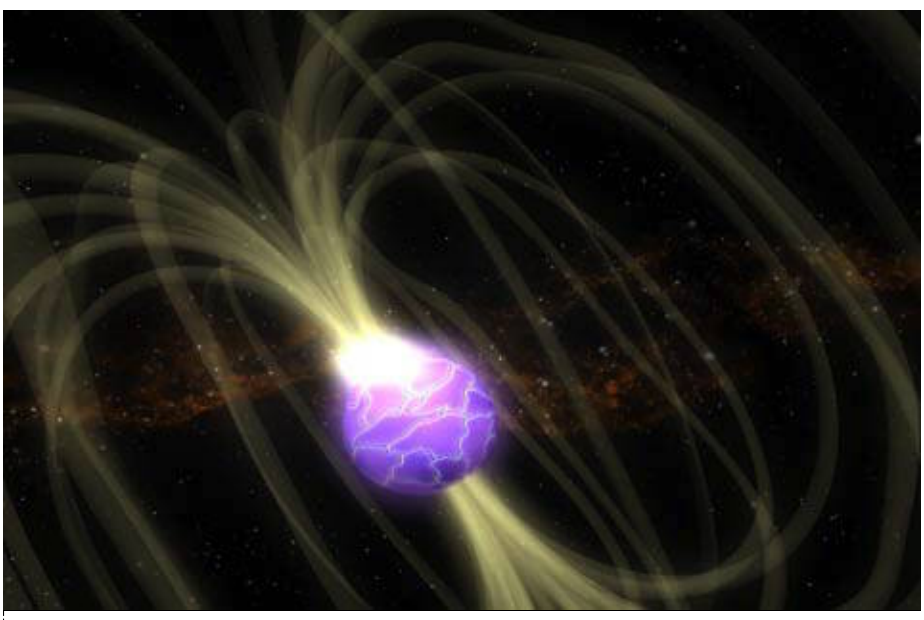
Q: If nothing, not even light, can escape a black hole, then why do nearly all artist renderings of black holes show an accretion disk and a jet that appears to spew out particles perpendicular to the disk? — **JOHN PELLEGRINI,** PHILADELPHIA

A: The accretion disk, X rays, and the rest of what you see in an artist's conception of a black hole aren't coming from inside the hole. Particles are falling into the black hole.

The key concept here is what is known as the black hole's "event horizon." Think of this as the "point of no return." Once matter reaches this event horizon, all of the standard folklore about black holes applies. Nothing inside the event horizon can ever get out again, not even light.

The event horizon is often called the "Schwarzschild radius" of the black hole. The term takes its name from theoretical physicist Karl Schwarzschild (1873–1916). Schwarzschild first used Einstein's equations of general relativity to predict the existence of black holes in 1916.

What happens, mathematically, at the Schwarzschild radius is that the metric — the grid that marks out space and time — becomes so distorted, it exhibits what theoretical physicists call a singularity. This, in effect, decouples the universe inside the radius from the rest of the universe. This is a mathematical way of



NASA

A MAGNETAR'S MAGNETIC FIELD LINES break apart and reconnect following a sudden surface disturbance in this artist's concept. Astronomers theorize reconnecting magnetic field lines release intense surges of energy they call magnetar flares.

IN THE KNOW

ACCRETION DISK
A disk of matter surrounding a black hole or star in which matter gravitationally spirals toward the central object.

CONSTELLATION BOUNDARY
A line surrounding an area of sky that defines celestial objects associated with a constellation.

MAGNETAR
A neutron star with an intense magnetic field. A neutron star forms when the core of a massive star collapses.

STAR QUAKE
A sudden disturbance on the crust of a neutron star.

saying that nothing, not even light, can ever escape the clutches of a black hole.

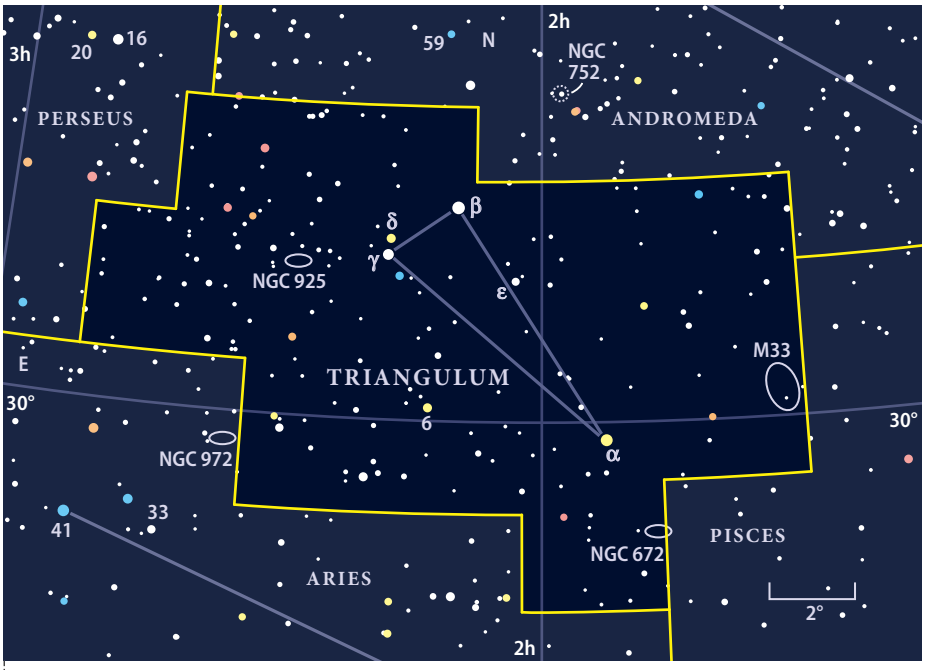
The Schwarzschild radius is very small — a little over a mile for an object the mass of the Sun — so gravity near a black hole is very strong. Matter falling into the black hole gets jammed together, which causes it to heat up and give off radiation. This kind of radiation is garden variety stuff — what you'd get if you heated matter in a laboratory. It is not the same as Hawking radiation, but that's a subject for another question. — **JAMES TREFIL,** CLARENCE J. ROBINSON PROFESSOR OF PHYSICS, GEORGE MASON UNIVERSITY

NO GREEN STARS

Q: Why are there no green stars? — FRANK STONESTREET, MOLINE, ILLINOIS

A: Green stars do exist. A star's color indicates its temperature. Green stars emit radiation most intensely at wavelengths in the green part of the visible-light spectrum. They also emit radiation over the range of visible-light wavelengths.

White light contains all the visible-light colors smeared together. The human eye detects green, but green is in the middle of the visible-light spectrum. **Your eyes see white when looking at a star emitting its peak radiation in the green part of the visible-light spectrum.** — **LAURA LAYTON,** ASSOCIATE EDITOR



CONSTELLATION BOUNDARIES (yellow) separate one constellation from another. Astronomers formalized these boundaries only in 1928. *ASTRONOMY:* ROEN KELLY

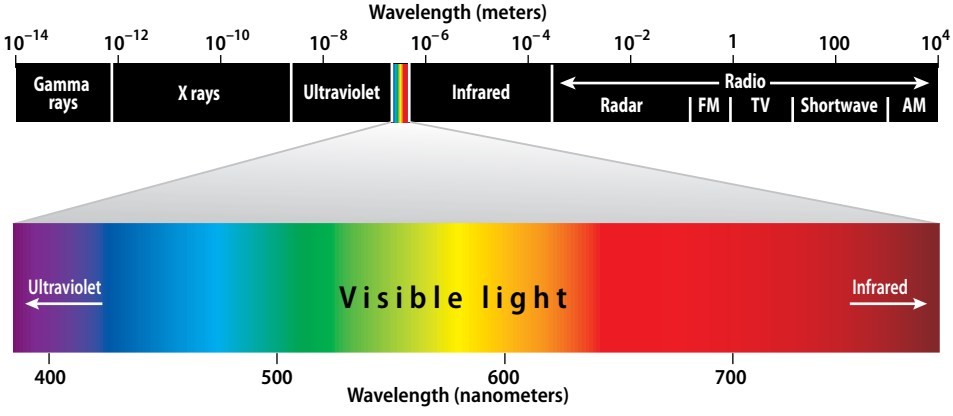
CONSTELLATION BOUNDARIES

Q: Can you explain why irregular constellation boundaries appear in various star atlases? — JACK WHITMAN, PHILADELPHIA

A: The 88 constellation boundaries were formalized in 1928 by a commission sanctioned by the International Astronomical Union. A publication announcing the boundaries appeared in 1930, authored by Belgian astronomer Eugene Delporte. This publication gave strict boundaries for each constellation. It left no blank spaces between constellations, and there was no overlap or shared stars. No variations exist between star atlases currently in use.

But **in star atlases of a century ago, astronomers chose to follow historical precedent and kept many borders as they had been known for centuries.** This explains much of the "wandering nature" of the constellation boundaries. But most, if not all, star maps published since 1930 show the same boundaries. — **MICHAEL E. BAKICH,** SENIOR EDITOR

The electromagnetic spectrum



VISIBLE LIGHT contains a rainbow of colors. Green light falls near the middle of the spectrum. At this wavelength, your eyes see white instead of green. *ASTRONOMY:* ROEN KELLY

COMING NEXT MONTH ...

What effects would a closer Moon orbit, or a Moon-Earth impact, cause? Post your comments about this question online at www.astronomy.com/forums.

Send your questions via e-mail to: askastro@astronomy.com; or write to: Ask Astro, P. O. Box 1612, Waukesha, WI 53187. Be sure to tell us your full name and where you live. Unfortunately, we cannot answer all questions submitted.

GENUINE LUMICON EQUIPMENT

PREMIUM QUALITY ASTRONOMICAL FILTERS

TELESCOPE COMPUTERS

CAMERA ADAPTERS & EASY GUIDERS

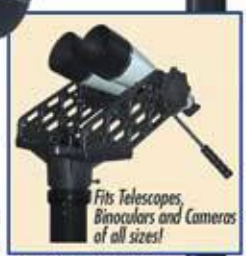
MULTIPLE FILTER SELECTORS

LASER POINTER BRACKETS

DIAGONALS & FOCAL REDUCERS

UTILITY TRAY SYSTEMS

FINDERSCOPES & BRACKETS



MADE IN THE USA

EXTENSION TUBES & ADAPTERS

THERE IS NO SUBSTITUTE!

See the full line of genuine Lumicon products and find your nearest authorized dealer at www.lumicon.com

LUMICON

NEW Portable Height Adjusting Pier

NEW UNIVERSAL PIER

LUMICON INTERNATIONAL 750 Easy Street · Simi Valley, CA 93065 US 800.420.0255 · 805.520.0047

Join *Astronomy* magazine and astronomers from around the world as we visit some of Chile's largest observatories and stand in awe under the pristine skies of the Atacama Desert to view the glories of the southern sky.

Tour accompanied by *Astronomy* Senior Editor Rich Talcott.

Seth Shostak

Seth Shostak

Seth Shostak

Seth Shostak

August 11–19, 2007

Tour includes:

- Round-trip airfare from Los Angeles, New York, or Miami
- All flights within Chile
- First class hotels and lodges throughout
- Meals: All breakfasts, 2 lunches, 6 dinners
- First class motor-coach travel
- Santiago city tour with guide
- Chilean wine tasting
- Visits:
  - Chilean Observatories: Cerro Tololo, Gemini South, Mamalluca, Chuquicamata Villages
  - Archaeological Indian sites and Spanish colonial villages
  - El Tatio geysers
  - Valle de la Luna
- *Astronomy* magazine lecturer, Rich Talcott
- Commentary and services of a fully experienced guide from MWT Associates
- All transfers and service charges
- All baggage handling for one large bag plus a telescope or camera
- All entrance fees to observatories and other attractions

For more information contact:

MWT Associates, Inc. • www.melitatrips.com

1-877-707-7827 • CST: 2040611040

Inspiring the Stargazer in You

Astronomy magazine

TUR-ADH-06X1406RH

THE ULTIMATE IN ASTRONOMY SHOPPING:
www.adorama.com

MEADE

DEEP SKY IMAGER II / PRO II

Deep Sky Imager II (CLR)	$599.00
CCD Color Filter Set	$199.00
Deep Sky Imager Pro II	$599.00
Deep Sky Imager Pro II w/RGB	$699.00

- Dramatically lower noise
- Larger (1/2" chip)
- 74% Higher resolution (752x582)
- Greater sensitivity
- Temperature sensor

ETX PREMIER EDITION

Automatic Alignment + SmartFinder

Meade's new ETX-Premier Edition automatically levels your telescope, points it to North and sets the time.
You just enter your location or zip code. After your ETX completes its patented Level North automatic alignment procedure it will point to the first alignment star. Use the new wide-field SmartFinder to center the red dot over the alignment stars for ultra-precise pointing accuracy. It's that easy.

KEY FEATURES

- Electronic Level Sensor
- Electronic Magnetic North Sensor
- High Precision Internal Clock
- Red Dot Viewfinder (SmartFinder™)

ETX PREMIER	Price
90 PE w/UHTC	$749.00
125 w/UHTC	$1,194.00

PRICES INCLUDE SHIPPING

COME SEE OUR NEW ASTRONOMY SHOW ROOM ON THE 5TH FLOOR

LX90 GPS SERIES

The Meade 8, 10, & 12" LX90
Includes with MgF2 coatings on the correcting lens and standard aluminum coatings on the primary and secondary mirrors (Ultra-High Transmission Coatings available optionally).

Camera Adaptable

KEY FEATURES

- GPS & Level North Technology
- Smart Drive, Autostar Controller
- Oversize Primary Mirror, Diffraction - Limited Optics
- Rigid Cast Aluminum Fork Mount
- LX-200 Series Tripods
- Smart Finder (Red Dot) & 8x50 View Finder
- AutoStar Suite Astronomer's Edition Software

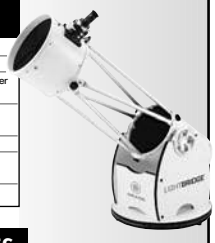
LX90	Price
8" w/UHTC	$1,999.00
10" w/UHTC	$2,699.00
12" w/UHTC	$3,299.00

PRICES INCLUDE SHIPPING

LIGHTBRIDGE DOBSONIANS

KEY FEATURES
FEATURES DELUXE

- Diffraction Limited Optics
- Meade Optical Coatings
- 2" Crayford-Style machined aluminum focuser w/1.25" adapter
- Advanced Red-Dot Finder (includes four reticles)
- Steel RA roller bearings
- 26mm QX™ Wide Angle 2" Eyepiece (70° field-of view)
- Built-in Primary Mirror Cooling Fan



DELUXE	PRICE
8"	$599.00
10"	$799.00
12"	$999.00
16"	$1,999.00

PRICES INCLUDE SHIPPING

ACCESSORIES	
1.25" Laser Collimator	69.95
Light Shroud for 8"	35.00
Light Shroud for 10"	40.00
Light Shroud for 12	45.00

ASTRONOMY BINOCULARS

Great for viewing The Heavens

Nikon PENTAX FUJINON Canon MEADE

We Stock The Complete

WE ALSO STOCK THESE OTHER FINE LINES

Thousand Oaks Optical
LUMICON
PARALLAX INSTRUMENTS
STARLIGHT INSTRUMENTS
TELRAD
STARRY NIGHT
RIGEL SYSTEMS
SWAROVSKI OPTIK
ZEISS Vixen Leica
SOFTWARE BISQUE

TAKAHASHI

FS-60, Sky-90, FS-102, TOA-130, LE Eyepieces, **IN STOCK!**

Check Our Web Site For Details www.adorama.com

CORONADO

PST, SolarMax 40 Telescopes, 60 & 90mm systems

Check Our Web Site for a Full Listing

Apogee INSTRUMENTS INC

Check Our Web Site for a Full Listing

STAR-BOUND

Viewing Chair

THE PERFECT CHAIR FOR ASTRONOMY VIEWING COMFORT

ADJUSTABLE FROM 9"-32", FOLDS FLAT, POWDER COATED WHITE OR BLACK

$159.00

Tele Vue®

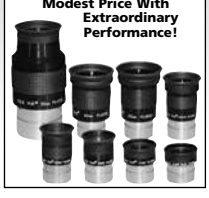
Adorama's 20th Year Proudly Selling Tele Vue

GIBRALTAR MOUNT

The tripods are finely crafted and American made in a choice of solid ash or walnut wood for beauty and quick vibration dampening. for use with all Telescopes

PLOSSL EYEPIECES

Modest Price With Extraordinary Performance!



BINO VUE

Open both eyes and see the dramatic improvement in resolution, contrast, faint star detection and viewing comfort.

NEW TELE VUE IMAGING SYSTEM TELESCOPES

Same wonderful performance, versatility for the visual observer however with significant added benefits for astrophotographers.

Includes:

- New 4 Element, flat field optical design with larger rear lenses for chips up to 50mm diagonal
- New Larger Focuser with 2.4" output diameter,
- Focusmate installed,
- New custom fitted case
- 2" Accssory adapter with clamp ring and photographic adapter

NAGLER EYEPIECES

82° FEILD "SPACE WALK" VIEWING

PANOPTIC EYEPIECES

TACK SHARP 68° FEILD

BANDMATE FILTERS

DIOPTRX™

EYE SIGHT Astigmatism correctors

RADIAN EYEPIECES

60° FEILD 20mm Eye-Relief

SHIPPING INSTRUCTIONS See Our Web Site WWW.ADORAMA.COM For Shipping Charges And Relevant Information.

ADORAMA INC.
Source for the **Educated Photographer**
42 West 18th Street New York, N.Y. 10011 info@adorama.com
www.adorama.com • Order Toll Free USA / Canada 800-223-2500
Orders & Information - 212-741-0052

BRIGHT-SKY OBSERVING

You'll have no problem seeing these celestial beauties through a small telescope, even through haze and light pollution. /// BY JAMES MULLANEY

Observe the sky's most colorful double stars

Observing double stars is one of the most enjoyable, yet neglected, aspects of stargazing. Even small telescopes can resolve thousands of these jewel-toned pairs, and no two look exactly alike. Also, you can enjoy them on nights that are all but useless for viewing other deep-sky wonders because of haze, bright moonlight, or light pollution.

While well-known blue-white pairs like Mizar (Zeta [ζ] Ursa Majoris) and Castor (Alpha [α] Geminorum) or golden ones like Algeiba (Gamma [γ] Leonis) look beautiful through the telescope, it's those doubles displaying a marked color contrast that most observers find exciting.

You'll discover targets among the naked-eye stars, which split easily. As author J. Dorman Steele pointed out more than a century ago, "Every tint that blooms in the flowers of summer flames out in the stars at night." And while many of these colors are illusory — the result of contrast effects between stars of different brightnesses — in other cases, they are definitely real.

Here are 21 of my favorite colorful doubles. Arranged in order of right ascension, they'll provide you with a year's worth of viewing pleasure. For maximum effect, use the lowest magnification that will split each pair. Sometimes, slightly defocusing the image (which poor seeing often does for you anyway) will help you perceive subtle hues by spreading the light over a greater area of the eye's retina.

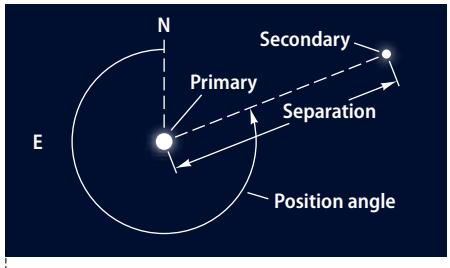
James Mullaney *has logged 20,000 hours observing. His book,* Double & Multiple Stars & How to Observe Them *(Springer, 2005), lists many more double-star targets.*

Twin treats of autumn

Cassiopeia holds a little-known gem — **Struve 3053** — whose gold and blue hues remind some observers of famed Albireo (in the summer section). Although noticeably fainter than Albireo, Struve 3053 is an easy catch in a 3-inch scope at 30x. It looks best through an 8-inch at 60x.

Eta (η) Cassiopeiae is a beautiful double with a yellow primary 4 magnitudes brighter than its ruddy-purple companion — the latter has been described as garnet, lilac, lavender, and even orange by various observers. A 2-inch at 25x shows the fainter star's distinctive hue, but Eta becomes ever more striking as aperture increases. Through a 10- or 12-inch at 60x or more, prepare to be wowed.

One of the sky's most colorful double stars is **Almach** (Gamma [γ] Andromedae). Its primary star shines with a magnificent topaz hue, and the companion appears aquamarine. These colors are superb through a 4-inch telescope at 50x to 100x.



DOUBLE-STAR nomenclature is simple. The "primary" is the pair's brighter star, and astronomers consider it the system's center. The fainter star is the companion, or "secondary." "Separation" measures the distance between the stars in arcseconds. Astronomers measure "position angle" in degrees from north (0°) through east (90°) and continuing back to north (360°).

ASTRONOMY: ROEN KELLY

Because its separation is only 10", this is one double that doesn't lose its impact through large telescopes. Observers tend to use higher magnifications with larger scopes, which have longer focal lengths. This often unduly spreads out wider pairs.

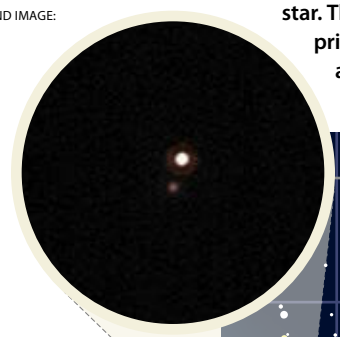
Winter beauties

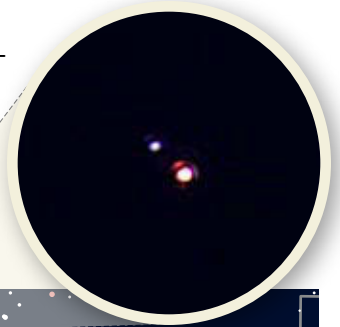
Below Orion, in Lepus, you'll find **Gamma (γ) Leporis**, an attractive, wide pair for low-power scopes. This pair displays a yellowish primary and a garnet secondary. *Astronomy* columnist Phil Harrington describes this double as "awash in vivid color" and considers it one of the finest binocular duos in the sky. While a pretty sight through a 2-inch refractor at 25x, it's too spread out for optimum effect at higher magnifications.

▲ DOUBLE STARS make easy targets for telescopes of all sizes. Many doubles combine stars of striking colors. Because stars are point sources, you can observe the brightest even under bright skies. ASTRONOMY: THEO COBB; BACKGROUND IMAGE: JOHN CHUMACK

▶ RAS ALGETHI'S (Alpha [α] Herculis) primary varies from magnitude 2.7 to 3.9, while the companion remains at magnitude 5.4. DAMIAN PEACH; ALL STAR CHARTS: *ASTRONOMY*: RICHARD TALCOTT AND ROEN KELLY

▼ 70 OPHIUCHI exhibits unusual colors for a double star. This pair combines a magnitude 4.2 yellow primary with a red companion that shines at magnitude 6.2. DAMIAN PEACH

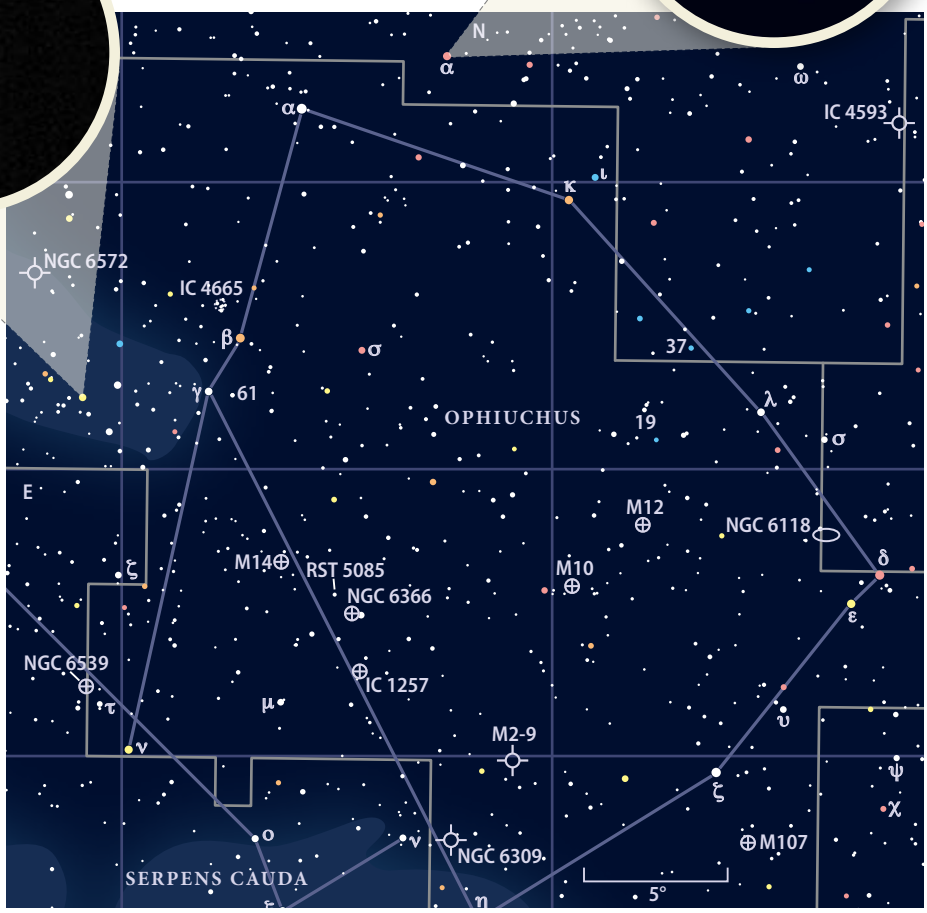




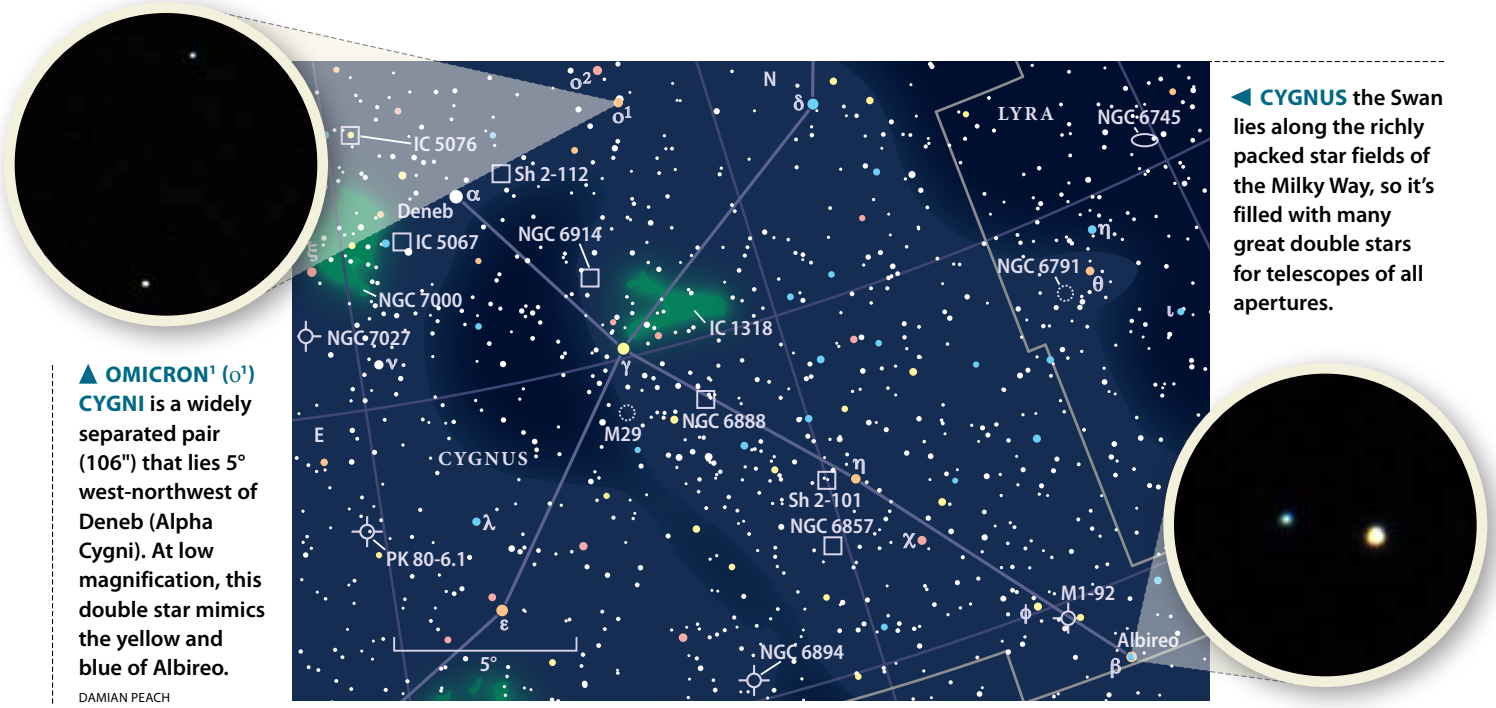
In an article several years ago, I dubbed **h3945** in Canis Major the "winter Albireo," and the name seems to have caught on. This magnificently tinted combo shines fiery-red and greenish-blue. Both stars appear striking through a 3-inch scope at 30x and superb in a 6-inch at 50x. The "h" prefix indicates this is one of English astronomer John Herschel's (1792–1871) many double-star discoveries.

Spring's special pairs

Iota (ι) Cancri is a striking orange-and-blue double star you can just resolve through 7-power binoculars. It's a lovely sight through even the smallest telescope. Well-known Pennsylvania double-star observer Sissy Haas thinks this pair has the most striking color-contrast in the sky, as seen through her 2.4-inch refractor. She even claims it's



OPHIUCHUS THE SERPENT-BEARER is a huge constellation that lies north of the Milky Way's center. Hercules lies on its northern border. ALL CHARTS: RICHARD TALCOTT AND ROEN KELLY



◀ CYGNUS the Swan lies along the richly packed star fields of the Milky Way, so it's filled with many great double stars for telescopes of all apertures.

▲ OMICRON[1] (o[1]) CYGNI is a widely separated pair (106") that lies 5° west-northwest of Deneb (Alpha Cygni). At low magnification, this double star mimics the yellow and blue of Albireo. DAMIAN PEACH

better than Albireo (see below). People's color perception varies, so be sure to check out Iota for yourself.

Vivid orange and emerald seem to best describe the tints of **24 Comae Berenices**. It's an exquisite sight through a 4-inch at 45x, and it's waiting for you among the many faint lights of this galaxy-rich constellation. You won't need a large telescope to reveal this pair's 5th-magnitude primary and its magnitude 6.3 secondary.

Called Pulcherrima, the "most beautiful one," by Russian double-star observer Wilhelm Struve (1793–1864), **Izar** (Epsilon [ε] Boötis) needs relatively high magnification and good seeing for a clean split through small scopes. A 5-inch at 100x does it. A 3-inch at 150x shows its golden-yellow and blue-green disks nearly in contact — a truly awesome sight!

Xi (ξ) Boötis is a yellow and reddish-purple pair sure to both surprise and thrill any observer seeing it for the first time. Absolutely exquisite through a 6-inch telescope at 50x, these tints hold up well in big scopes, which often saturate the colors of brighter doubles from too much light. In such cases, stopping down the aperture helps.

▲ ALBIREO (Beta [β] Cygni) marks the head of Cygnus the Swan. Albireo may be the best-known double star in the sky. Its gold and sapphire components glow at magnitudes 3.4 and 4.7, respectively. DAMIAN PEACH

/// 19 COLORFUL DOUBLE STARS FOR ALL TELESCOPES

Double star	Constellation	R. A.	Dec.	Magnitudes	Separation
Struve 3053	Cassiopeia	0h03m	66°06'	5.9, 7.3	15"
Eta Cas	Cassiopeia	0h49m	57°49'	3.4, 7.4	13"
Almach	Andromeda	2h04m	42°20'	2.3, 5.0	10"
Gamma Lep	Lepus	5h44m	–22°27'	3.6, 6.3	97"
h3945	Canis Major	7h17m	–23°19'	5.0, 5.8	27"
Iota Can	Cancer	8h47m	28°46'	4.1, 6.0	31"
24 Com	Coma Berenices	12h35m	18°32'	5.1, 6.3	21"
Izar	Boötes	14h45m	27°04'	2.6, 4.8	3"
Xi Boo	Boötes	14h51m	19°06'	4.8, 7.0	6"
Kappa Her	Hercules	16h08m	17°03'	5.1, 6.2	27"
Antares	Scorpius	16h29m	–26°26'	0.9–1.2, 5.4	3"
Ras Algethi	Hercules	17h15m	14°23'	2.7–3.9, 5.4	5"
Omicron Oph	Ophiuchus	17h18m	–24°17'	5.2, 6.6	10"
95 Her	Hercules	18h02m	21°36'	4.8, 5.2	6"
70 Oph	Ophiuchus	18h06m	–2°30'	4.2, 6.2	5"
Albireo	Cygnus	19h31m	27°58'	3.4, 4.7	35"
Omicron[1] Cyg	Cygnus	20h14m	46°44'	3.8, 7.0	106"
Gamma Del	Delphinus	20h47m	16°07'	4.4, 5.0	9"
Delta Cep	Cepheus	22h29m	58°25'	3.4–4.4, 6.1	41"

Key: R. A. = Right ascension (2000.0), Dec. = Declination (2000.0)

Hot colors of summer

If you liked Xi Boötis, **Kappa (κ) Herculis** appears as a wider clone of it. An easy split through a 2-inch telescope at 25x, the colors here are yellow and garnet, with the latter perhaps tinged with a bit of orange. Kappa's stars lie 27" apart and shine at magnitudes 5.1 and 6.2.

Antares (Alpha [α] Scorpii) marks the toughest, but most spectacular pair (at least as viewed through large scopes), in our lineup. The fiery-red primary is closely attended by a companion that can be described only as emerald-green. But is the green color real?

English observer and author William H. Smyth (1788–1865), observed the companion emerge from an occultation by the Moon before the primary. The green hue Smyth saw, therefore, did not result from a

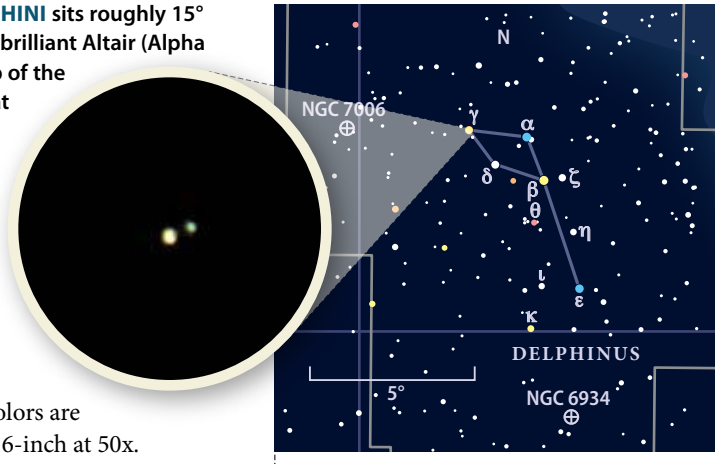
contrast effect with the primary. Similar recent observations attribute a blue color to the companion.

You can split Antares through a 5-inch telescope at 100x on nights when the seeing is good. Seen through a 13-inch refractor at 190x, it is perhaps the most spectacular colored double star in the entire sky!

The cozy orange and blue-green pair comprising **Ras Algethi** (Alpha Herculis) reminds some observers of an easier-to-split Antares. A 2.4-inch scope at 75x will divide these two stars nicely, and they make a lovely sight through an 8-inch at 100x. The magnification needed to resolve Ras Algethi depends on the changing brightness of the variable primary.

Omicron (o) Ophiuchi tends to be overshadowed by the many globular clusters found in this region, but be sure to seek it out. These pale-orange and clear-blue jewels separated by a scant 10" are superb through a 3-inch scope, even at 30x.

You've got to see **95 Herculis** to believe it! The colors are just as Smyth described them more than 150 years ago: apple-green and cherry-red. These amazing hues glow subtly but persistently through all telescope apertures, but the colors are best seen through a 6-inch at 50x.



GAMMA (γ) DELPHINI sits roughly 15° east-northeast of brilliant Altair (Alpha Aquilae) at the tip of the parallelogram that forms the small constellation Delphinus. Typically, observers describe this pair's colors as yellow and lime-green. DAMIAN PEACH

DELPHINUS the Dolphin contains several nice deep-sky objects, such as globular cluster NGC 7006. Its finest double star is Gamma Delphini. RICHARD TALCOTT AND ROEN KELLY

70 Ophiuchi is a close double with an entirely different kind of color contrast than most of those in this list — yellow and red. Snug in a 3-inch at 100x, a 10-inch at double that magnification separates the pair beautifully. Some observers report seeing a persistent touch of violet in the 6th-magnitude companion. The hue you detect depends on your eyes' color perception.

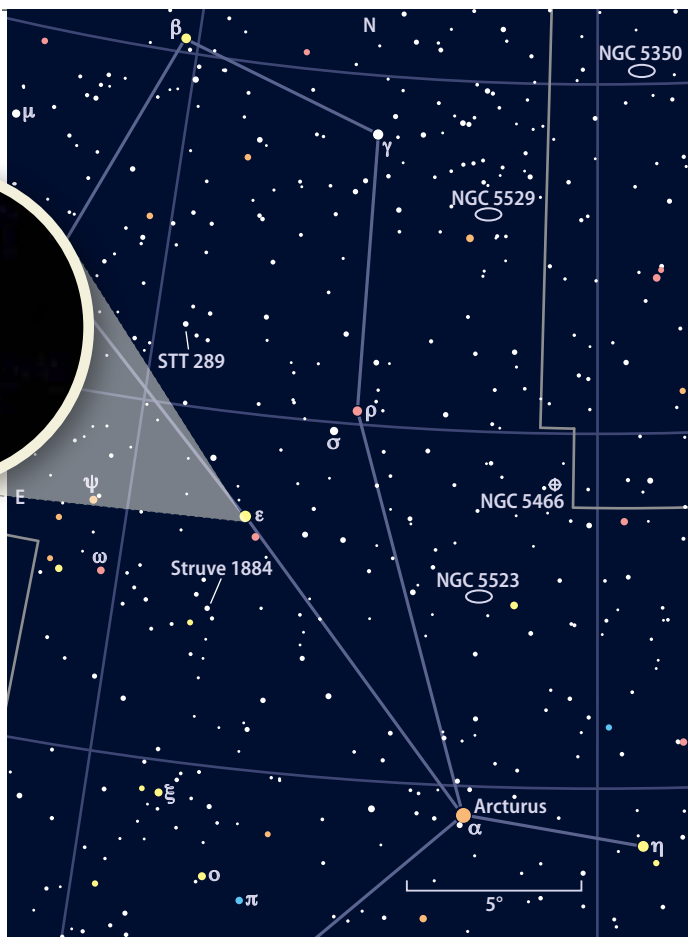
The magnificent **Albireo** (Beta [β] Cygni) bears the moniker "everyone's favorite double star," and for good reason. Its glorious orange and blue colors are unmistakable even in a 2-inch at 20x, and can be seen even in 10x50 binoculars. And the colors are definitely real — as you can prove by attaching a narrow strip of aluminum foil across your eyepiece's field stop. Hiding either star behind the strip has no effect on the color of the other!

As if Albireo isn't enough, Cygnus offers another highly tinted double that's also striking through small telescopes — **Omicron¹ (o¹) Cygni**. The hues here mimic those of its famous neighbor, but the two suns are much farther apart so the contrast isn't quite as dramatic. There's also a magnitude 4.8 bluish-white star 331" distant, making this an apparent triple system.

The lovely yellow and pale-green double **Gamma Delphini**, with a separation of 9", resolves neatly through a 3-inch telescope at 45x. Through 6-inch and larger scopes, it's one of the finest doubles in the sky. There's also a ghostly-looking double lurking in the same field of view. Designated Struve 2725, its magnitude 7.6 and 8.4 components lie just 6" apart and contribute to the scene's fascination.

Delta (δ) Cephei happens to be the prototype of the famed Cepheid variables that astronomers use to gauge distances in space. Unfortunately, as such, it's often overlooked as an attractive double star. Its pale yellowish-orange and blue components are a lovely sight through a 4-inch telescope at magnifications as low as 16x.

A number of writers over the years have looked poetically upon the stars as "flowers in the meadows of heaven." A leisurely romp through the colorful starry jewels in this list should convince you they are, indeed, just that.



▶ BOÖTES contains lots of bright double stars, but few as bright as Izar.

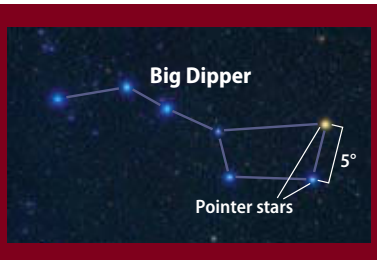
▲ IZAR (Epsilon [ε] Boötis) combines the light of magnitude 2.6 and 4.8 stars. If you have trouble finding it, just look 10° northeast of Arcturus (Alpha Boötis). The components of this double star lie only 3" apart, so use high magnification to split them. DAMIAN PEACH

If you've ever wondered about some of the terms astronomers use, here's an illustrated guide. /// **BY MICHAEL E. BAKICH; ILLUSTRATIONS BY ROEN KELLY**

An easy guide to astro-speak

This article is for all you dictionary

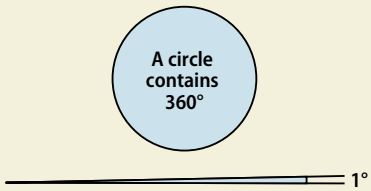
users. If you're often confused by astronomy terms, your friends don't have to find out. Just rip this article out of the magazine, and hide it where it's handy. Don't feel bad about it. Your friends probably will do the same thing.



APPARENT SIZE

HOW BIG an object appears to us has nothing to do with its real size. What matters more is the distance between us and the object.

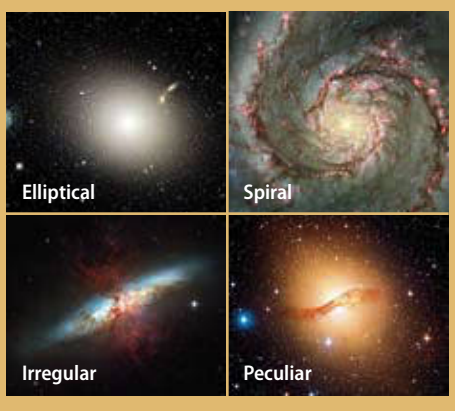
MEASURING ANGLES



1 arcminute (1') = 1/60°
1 arcsecond (1") = 1/3,600°

ANGULAR MEASURE in astronomy confuses beginners because small angles use the same symbols as feet and inches. When astronomers describe the apparent size of a celestial object, 1' describes an angle of 1 arcminute (1⁄60 of a degree). Likewise, 1" defines the small angle of 1 arcsecond (1⁄60 of an arcminute). For a quarter to subtend an angle of 1", you would have to view it from about 3 miles (5 kilometers) away.

Michael E. Bakich *is a senior editor of* Astronomy.



KNOW THE FOUR BASIC TYPES OF GALAXIES

Four main galaxy classifications exist. **Elliptical galaxies** have shapes that range from round to long and thin. They contain old stars, little gas, and few star-forming regions. Giant ellipticals are the largest galaxies, while dwarf ellipticals rank as the smallest.

Spiral galaxies look like pinwheels, or would if their orientations all were face-on to our point of view. Spirals contain a central bulge surrounded by a disk, and many spirals (such as the Milky Way) feature a central bar from which their arms originate.

Irregular galaxies generally appear featureless. They don't fall into either elliptical or spiral categories. Many have star-forming regions.

Astronomers classify **peculiar galaxies** unusual in one or more ways such as brightness, amount of dust, or shape. Peculiar galaxies generally form because of gravitational interactions between galaxies.

ELLIPTICAL: CANADA-FRANCE-HAWAII TELESCOPE/J.-C. CUILLANDRE (CFHT)/COELUM; SPIRAL: N. SCOVILLE (CALTECH)/T. RECTOR (U. ALASKA, NOAO) ET AL., HUBBLE HERITAGE TEAM/NASA; IRREGULAR: NASA/ESA/THE HUBBLE HERITAGE TEAM; PECULIAR: J.-C. CUILLANDRE (CFHT)/HAWAII STARLIGHT/CFHT

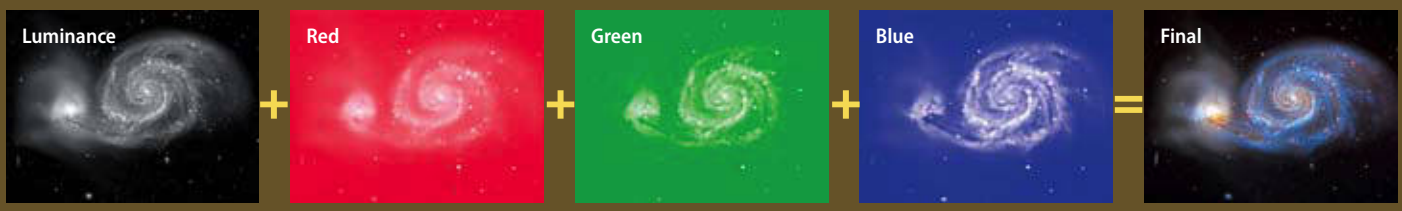
DON'T LET NEBULA NOMENCLATURE SCARE YOU

ASTRONOMERS DIVIDE NEBULAE into four categories. **Emission nebulae** glow red because their hydrogen atoms absorb ultraviolet radiation from nearby hot stars and reemit it as reddish light. **Reflection nebulae** shine with a bluish tint because they reflect and scatter starlight. Earth's clear daytime sky appears blue also because of scattering.

Planetary nebulae (named two centuries ago because they appeared disk-like) form from Sun-like stars near the end of their lives. The star's outer layers slowly expand away from the hot core until the core no longer illuminates them. **Dark nebulae**, huge clouds made of dust and cold gas, block the light from stars and bright nebulae behind them.

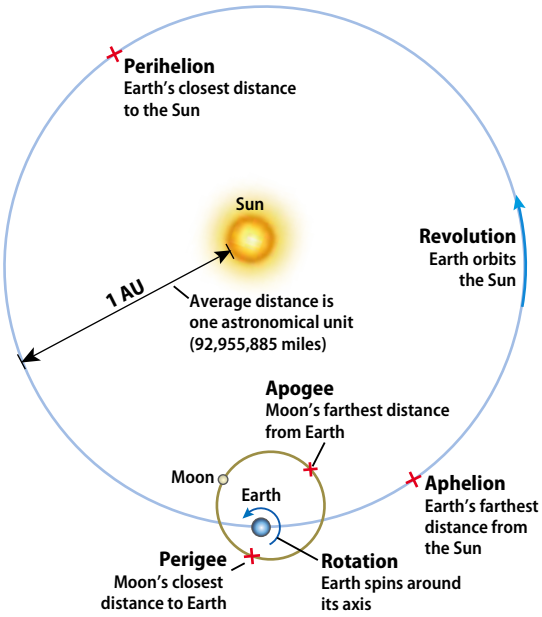
EMISSION: NASA/ESA/THE HUBBLE HERITAGE TEAM; REFLECTION: DANIEL VERSCHATSE/ANTILHUE OBSERVATORY; PLANETARY: THE HUBBLE HERITAGE TEAM (STScI/AURA)/NASA; DARK: FORS TEAM/8.2-METER VLT ANTU/ESO

COLOR FROM CHARGE-COUPLED DEVICE (CCD) IMAGES



THE TERM "LRGB" refers to color-filtered black-and-white images obtained with a CCD (digital) camera. Imagers combine these exposures to form a color image. L stands for luminance, usually an unfiltered exposure designed to capture detail. R, G, and B define exposures through red, green, and blue filters, respectively. These exposures capture the object's color information. TONY AND DAPHNE HALLAS

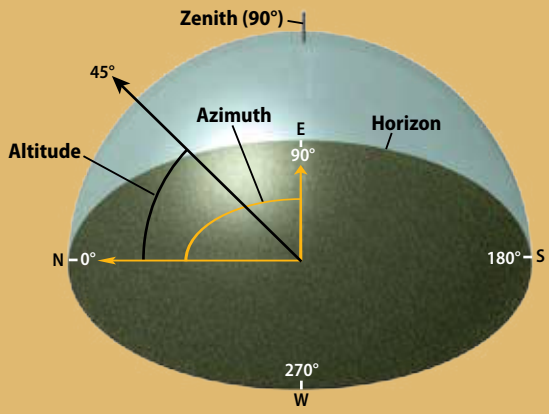
ROUND AND ROUND



PLANET MOTIONS and positions include similar-sounding terms. **Rotation** means spinning. Earth rotates once a day. **Revolution** means orbiting another object. Earth revolves around the Sun once a year. The average Earth-Sun distance is an astronomical unit (92,955,885 miles, or 149,598,871 km).

For other terms, remember "peri" means "near" and "ap" means "far." An object's closest approach to the Sun is **perihelion**, and its farthest point is **aphelion**. **Perigee** is an object's closest approach to Earth. **Apogee** is the point where it lies farthest from Earth.

ALTITUDE AND AZIMUTH



THE ALTITUDE-AZIMUTH (alt-az) coordinate system is easy to learn. Azimuth measures an object's position (in degrees) along the horizon, starting at north (0°) and passing through east, south, and west. Altitude measures height above the horizon (0°). An object overhead has the maximum altitude — 90°. So, an object halfway up in the sky due west has an altitude of 45° and an azimuth of 270°.

STAR-CHART LINGO

LINES OF RIGHT ASCENSION
R.A. is the celestial equivalent to longitude. Astronomers attached the grid to the sky, so objects' right ascensions don't change as Earth rotates. R.A. is measured in hours, minutes, and seconds.

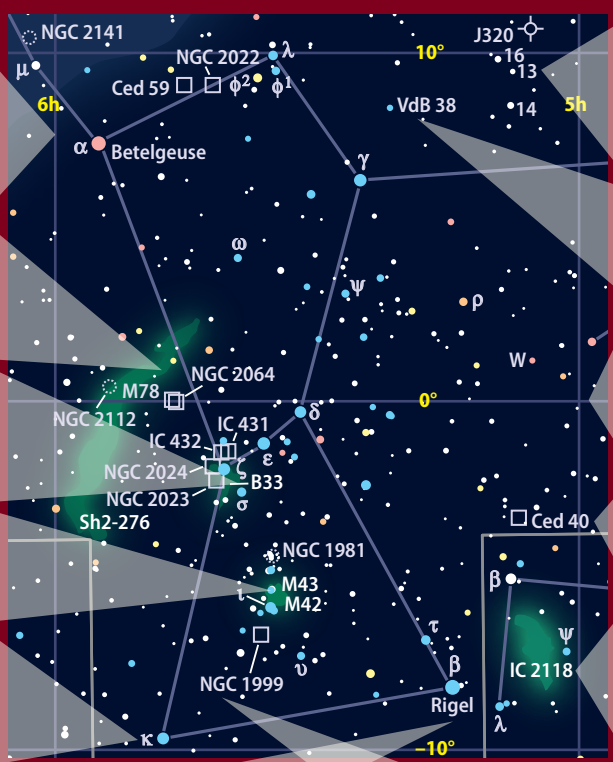
SHARPLESS OBJECT (Sh)
American astronomer Stewart Sharpless cataloged 313 HII regions (star-forming areas composed of hydrogen that glow because of irradiation from nearby stars).

BARNARD OBJECT (B)
American astronomer Edward Emerson Barnard (1857–1923) cataloged 349 dark nebulae in *A Photographic Atlas of Selected Regions of the Milky Way*.

MESSIER OBJECT (M)
French comet-hunter Charles Messier (1730–1817) created a catalog that contains 109 of the finest deep-sky objects.

BAYER (GREEK) LETTER
German mapmaker Johannes Bayer (1572–1625) labeled the brightest stars of each constellation using Greek letters. His system appeared in *Uranometria* in 1603.

STAR NAME
Some 200 bright stars have common names. Most star names come to us from Arab and Greek astronomers and their star charts.



FLAMSTEED NUMBERS
English astronomer John Flamsteed (1646–1719) produced *Atlas Coelestis*, published posthumously in 1729. In this atlas' French edition, numbers labeled each constellation's stars.

VAN DEN BERGH (VdB) OBJECT
Canadian astronomer Sidney Van den Bergh cataloged 158 reflection nebulae and published a catalog in 1966.

LINES OF DECLINATION (Dec.).
Measured in degrees, they form the second coordinate. The starting point is Earth's equator projected into space. Declinations north of the celestial equator are positive, and those south are negative.

CEDERBLAD (Ced) OBJECT
Swedish astronomer Stefan Cederblad cataloged 330 bright, diffuse galactic nebulae and published a catalog in 1946.

***INDEX CATALOGUE* (IC) OBJECT**
English astronomer John Louis Emil Dreyer (1852–1926) published two addenda to his *New General Catalogue* (see below), in 1895 (containing 1,529 objects) and 1908 (with 1,496 objects).

***NEW GENERAL CATALOGUE* (NGC) OBJECT**
In 1888, Dreyer listed 7,840 deep-sky objects in a catalog that appeared in *Memoirs of the Royal Astronomical Society*.

ORION 32 YEARS

ACCESSORY SALE!

EVERYTHING FOR THE AMATEUR ASTRONOMER — DELIVERED DIRECT

TELESCOPES

New Crayford-style focuser! (excl. XT6)

Bonus Accessory Pack
With Any Orion SkyQuest™ Classic or IntelliScope® Dobsonian
Up to $103.90 Added Value Included!

SkyQuest™ XT IntelliScope® Dobsonians

Space is infinite. Your patience is not. Avoid tedious truss-tube designs and get a Dob that's faster to set up, has a solid-wall tube for superior contrast, has altitude tension adjustment for optimal balance, is amply portable, and allows *computerized pointing* to 14,000+ objects.

XT12 IntelliScope . . $1,119.95* **XT8 IntelliScope . . . $619.95**
XT10 IntelliScope . . $789.95 **XT6 IntelliScope . . . $499.95**

* Prices *INCLUDE* optional Computerized Object Locator with 14,000-object database.

Computerized EQ Telescopes

Orion® SkyView™ Pro 8 EQ GoTo Reflector
Terrific deep-space probe with f/4.9 parabolic optics and auto-pointing GoTo system.
$1,079.95

Orion® Sirius™ 80ED EQ-G Apo Refractor
An outstanding instrument for CCD or DSLR imaging.
$1,299.95 with Dual-Axis Controller
$1,599.95 with GoTo Controller

Orion® Atlas™ 11 EQ-G Schmidt-Cassegrain
Take your deep-sky aspirations to the limit.
$2,699.95 with Dual-Axis Controller
$2,999.95 with GoTo Controller

New! Premium OTAs

Orion 180mm Maksutov-Cassegrain
Our biggest Mak delivers high-power performance. With 7" of aperture and 2700mm focal length (f/15), you'll get tack-sharp, high-contrast views and exquisite resolution.
$1,199 OTA

Orion® 120mm ED Apo Refractor
Take your observing and imaging to new heights! Premium "apo" refractor features 120mm (4.7") doublet lens, 900mm focal length (f/7.5), with Japanese FPL-53 "ED" glass to minimize chromatic aberration. Crayford-type 2" focuser with aluminum focus wheels; machined aluminum lens cell. OTA only, without accessories.
$1,999.95

ACCESSORIES

SkyLine™ Green Laser Pointer and Bracket for SkyScout
Cool accessory makes SkyScout Personal Planetarium even easier and more fun to use! Just aim the side-mounted SkyLine green laser pointer at any celestial object, then hit the Target button and read the description from SkyScout's LCD. You won't have to view through the SkyScout, and the green laser lets you and others see exactly whereSkyScout is pointed.

Dual-ring ABS bracket mounts securely to threaded socket on the side of SkyScout. Does NOT interfere with the SkyScout's GPS or pointing accuracy. Trick out your SkyScout today! SkyScout sold separately.

$124.95

New!

Orion® StarShoot Solar System Color Imager II
This next-generation SSSCI has a bigger (1/2"), higher-resolution 1.3 megapixel color CMOS chip, with 4x the number of pixels for finer detail in planetary, lunar, and solar images. Includes MaxIm DL Essentials software.
$179.95

New!

SALE! 15% OFF

Orion® Dielectric Diagonals
These premium diagonals yield 99% reflectivity.
1.25" Reg. $79.95 **Sale $67.95**
2" Reg. $119.95 **Sale $101.95**

SALE! 20% OFF

UltraBlock™ Nebula Filters
Dramatically improve contrast on emission nebulas to reveal more detail.

1.25"	2"	SCT
Reg. $79.95	Reg. $99.95	Reg. $109.95
Sale $63.95	**Sale $79.95**	**Sale $87.95**

Sale prices in effect through April 1, 2007.

Orion® Q70™ 2" Super-Wide Field Eyepieces

New!

Gargantuan 70-degree apparent field of view and fully multi-coated, 5-element optics make Q70s the best choice in affordable premium 2" eyepieces. Three focal lengths: 26mm, 32mm, 38mm.
$99.95 each

Orion® 2x Barlow Lenses
Double the magnifying power of any eyepiece with a Barlow lens.

Shorty 2x (1.25")
Reg. $39.95
Sale $31.95

SALE! 20% OFF

Shorty-Plus 3-Element 2x (1.25")
Reg. $79.95
Sale $67.95

SALE! 15% OFF

Orion 2" 3-Element 2x
Reg. $179.95
Sale $161.95

SALE! 10% OFF

MONEY-BACK 100% Satisfaction GUARANTEE

THE ULTIMATE IN ASTRO SHOPPING:
www.adorama.com

PREMIER SELECT CELESTRON DEALER

CPC Series
XLT Starbright H.P. Schmidt Cassegrain Telescope with NexStar Computer Control & SKyAlign Technology

Tomorrow's next generation 8, 9.25, and 11 computerized GPS SCT's are here now!

NexStar SE

NEW! Nexstar SE Series
4SE, 5SE, 6SE, 8SE,
INCLUDES:
- XLT Coatings
- Orange Removable OTA,
- 40,000 object database,
- Nexstar Remote Software,
- The Sky Software
- Adjustable Tripod

SkyAlign
USE NEARLY ANY 3 BRIGHT OBJECTS IN THE SKY TO ALIGN YOUR TELESCOPE!

STARTING AT
$599.00

CGE-1400, 14" Schmidt-Cassegrain Telescope with XLT Coatings & CGE German Equatorial Mount

- 14" (356mm) Schmidt-Cassegrain Optical Design
- 3910mm Focal Length, f/11
- StarBright Multi-Coating
- XLT Coating Optional
- Computerized Equatorial Mount
- 40,000+ object database with 400 user-defined objects. CompassCalibration, Polar Alignment routine, Auto North and Level, Quick Align.
- Super HD Tripod
- Computerized Hand Control
- RS-232 communication port on hand control
- Optical Tube Weight - 45 lb.
- Tripod/Mount Weight - 139 lb.

CELESTRON TELESCOPE ACCESSORIES

NexImage
Solar System Imager
NEXIMAGE ACCESSORIES

UV/IR CUT OFF Filter 52.95
Neximage Reducer.....21.95
2x Ultima Barllow Lens.....60.95

$99.95

EYEPIECES KITS

Includes: • 5 Superior Grade Plossl Eyepieces 1.25"(4mm, 6mm, 9mm, 15mm, & 32mm), • 2x Barlow Lens, • Six Colored Filters, • Moon Filter, • Aluminum Carrying Case
All for only **$129.95**

2" ACCESSORY KIT
Includes: • 3-2" Eyepieces, 2" 5 Color Filters, 2"Star Dia, 2" 2X Barlow Aluminum Case **$239.95**

BINOCULARS

25 x 100 SkyMaster, Weather Resistant Porro Prism Binocular with 3.0 Degree Angle of View, U.S.A.

- Waterproof
- BAK-4 Porro
- Multicoated Optics
- Long eye Relief
- Integrated Tripod Adapter
- Structural reinforcement of the main body for maximum stability

Celestron No Fault Limited Lifetime warranty

CELESTRON SKYSCOUT

SKYSCOUT PERSONAL PLANETARIUM

Introducing the SkyScout from Celestron: The SkyScout is a revolutionary, one of a kind, patented handheld device that instantly identifies and/or locates any celestial object visible to the naked eye, providing educational and entertaining information, both in text and audio.

A fun learning tool for all ages, the SkyScout personal planetarium puts the knowledge of an expert astronomer in the palm of your hand.

Item Includes: Carry Case, Earphones, Hand Strap, USB Cable

$399.95

ADORAMA INC.
Source for the **Educated Photographer**

ATOMIC TIME
1010 Jorie Blvd. #332
Oak Brook, Il 60523
1-800-985-8463
www.atomictime.com

ADWA101 - $49.95

12" LaCrosse Black Wall
WT-3123E $29.95
This wall clock is great for an office, school, or home. It has a professional look, along with professional reliability. Features easy time zone buttons, just set the zone and go! Runs on 1 AA battery and has a safe plastic lens.

Digital Chronograph Watch
ADWA101 $49.95
Our feature packed Chrono-Alarm watch is now available for under $50! It has date and time alarms, stopwatch backlight, UTC time, and much more!

WT-3123E - $29.95

WS-8248 - $64.95

LaCrosse Digital Alarm
WS-8248U-A $64.95
This deluxe wall/desk clock features 4" tall easy to read digits. It also shows temperature, humidity, moon phase, month, day, and date. Also included is a remote thermometer for reading the outside temperature on the main unit. approx. 12" x 12" x 1.5"

1-800-985-8463
www.atomictime.com
Quantity discounts available!

WS-9412U - $19.95

LaCrosse WS-9412U Clock $19.95
This digital wall / desk clock is great for travel or to fit in a small space. Shows indoor temp, day, and date along with 12/24 hr time. apx 6"x 6"x 1"

Tell time by the U.S. Atomic Clock -The official U.S. time that governs ship movements, radio stations, space flights, and warplanes. With small radio receivers hidden inside our timepieces, they automatically synchronize to the U.S. Atomic Clock (which measures each second of time as 9,192,631,770 vibrations of a cesium 133 atom in a vacuum) and give time which is accurate to approx. 1 second every million years. Our timepieces even account automatically for daylight saving time, leap years, and leap seconds. $7.95 Shipping & Handling via UPS. (Rush available at additional cost) Call M-F 9-5 CST for our free catalog.

NEAF NORTHEAST ASTRONOMY FORUM

16TH ANNUAL NORTHEAST ASTRONOMY FORUM & TELESCOPE SHOW
APRIL 28-29, 2007

AMERICA'S PREMIER ASTRONOMY EXPO!
Only 30 minutes from New York City at
SUNY Rockland Community College, Suffern, NY

THIS EXCITING 2-DAY EVENT FEATURES:
- More than 80 on-site vendors
- World-renowned speakers
- Astro-imaging workshops
- Daily solar observing
- STARLAB planetarium shows
- Getting started classes for beginners
- Space and astronomy events for kids

FEATURED SPEAKERS:
Br. Guy Consolmagno - The Vatican Observatory
Stephen O'Meara - Astronomy Magazine
Dr. Fulvio Melia - University of Arizona

SHOW HOURS:
SAT 8:30-6 PM, SUN 10-6 PM
For a detailed schedule, directions, admission information or hotel accommodations visit:
www.rocklandastronomy.com/neaf
or contact Alan Traino at 973-427-2020.

Presented by Rockland Astronomy Club New York

NORTHEAST ASTRO IMAGING CONFERENCE
APRIL 26-27, 2007 AT NEAF

FEATURING WORKSHOPS & LECTURES BY
Richard Berry, Adam Block, Alan Chen, Alan Holmes, Jerry Lodriguss, Brian Lula

The 100ED EQ-G's high-quality optics provide plenty of great sky views at a price that doesn't break the bank. /// **BY PHIL HARRINGTON**

Orion's new 4-inch powerhouse

Apochromatic refractors are famous

for producing sharp, contrasty images, whether it's the edge of Saturn's rings, the vivid colors in Jupiter's turbulent atmosphere, the magic of a tight binary star, or the glory of a star-packed cluster or a gossamer nebula. It's the apochromatic objective lens' design that gives images their sharpness and contrast. An achromatic refractor's objective uses two lens elements made from standard optical glass.

Apochromatic refractors use complex two-, three-, or four-element objectives with one or more elements of special, low-dispersion glass — often fluorite, SD (Special Dispersion), or ED (Extra-low-Dispersion) glass. The results are impressive, but so are their price tags.

In 2003, Orion Telescopes introduced the 3.1-inch f/7.5 80ED apochromatic refractor. This scope cost much less than same-size big-name apos, but could it really deliver top-end performance? I found the 80ED works surprisingly well. Orion quickly expanded its line of imported economy apos to include the 3.9-inch f/9 100ED and the 4.7-inch f/7.5 120ED.

Internal craftsmanship

All three telescopes employ two-element, air-spaced objective lenses. The outer (front) element in each is made of traditional optical glass, while the inner element is made from extra-low-dispersion FPL-53 Fluoro-crown glass.

Although fluorite is the best choice, pure fluorite's fragility makes it difficult to craft into a quality lens. FPL-53, however, is more durable and workable. Its optical qualities are similar to those of fluorite, making it the choice among many of today's apo manufacturers.

Another key factor in the 100ED's optical quality is its moderate focal ratio: f/9. This is crucial because the lower the focal ratio for a given aperture, the more chromatic aberration appears.

To enhance image contrast further, each element in the 100ED's objective is fully multicoated. "Fully multicoated" means each surface of all lenses receive the same

Phil Harrington *is the author of the observing guidebook* Star Watch *(John Wiley & Sons, 2003).*

/// SPECIFICATIONS

ORION 100ED EQ-G

Type: Apochromatic refractor
Aperture: 3.9 inches (100 millimeters)
Focal length: 900mm
Focal ratio: f/9
Tube length: 36 inches (91.4 cm)
Assembled weight: 40 pounds (18 kg)
Included: 26mm Plössl eyepiece, Crayford-style focuser, 1¼" prism star diagonal, 8x40 finder scope, illuminated polar-alignment scope
Mount: Computer-controlled Sirius EQ-G equatorial mount with full go-to control
Database: 13,400 objects
Price: $1,649

CONTACT INFORMATION

Orion Telescopes and Binoculars
P. O. Box 1815
Santa Cruz, CA 95061
[t] 800.447.1001
[w] www.telescope.com

THE OPTICS in the Sirius 100ED EQ-G are fully multicoated. The f/9, two-element, air-spaced objective combines an outer element of traditional optical glass with an inner element of extra-low-dispersion glass.

ORION'S SIRIUS 100ED EQ-G combines the 4-inch 100ED apochromatic refractor with the computer-controlled Sirius EQ-G mount. ALL PHOTOS: *ASTRONOMY*: JAMES FORBES

ACCESSORIES included with the Sirius 100ED EQ-G are an 8x40 finder scope (left), a 1¼" star diagonal (center), and a 26mm Plössl eyepiece, which yields 35x.

coating. The 100ED's optics display a deep-green tint when viewed in daylight.

Orion's 100ED is available in several configurations. You can buy the optical-tube assembly only, or you may purchase it with either the SkyView Pro or the heftier Sirius German equatorial mount.

Observatory in a box

The Sirius 100ED EQ-G pairs the 100ED with the computer-controlled version of Orion's Sirius mount. The Sirius EQ-G mount includes a heavy-duty equatorial head and tripod, go-to control — with a built-in 13,400-object library — and an illuminated polar-alignment scope.

Regardless of the mount you choose, each outfit includes a 1¼" prism star diagonal, a 26mm Plössl eyepiece (which yields 34.6x), and an 8x40 straight-through finder scope. Like many imported telescopes, the finder's mounting base uses two perpendicular thumbscrews and a spring-loaded piston to hold the finder in place. This makes aligning the finder a snap.

The 100ED's single-speed, Crayford-style focuser accepts either 1¼" or 2" eyepieces. Remove the 1¼" star diagonal, and you can thread a standard T-ring camera mount directly onto the focuser's drawtube. This proves handy when imaging through the telescope.

Even though the focuser operates smoothly, I found its motion to be coarse when I used high-magnification eyepieces and when I did astrophotography.

The Sirius mount's drive includes a periodic-error-correction (PEC) circuit the user can program to counter the cyclical wavering inherent in all worm-gear drives. Because the Sirius PEC circuitry has no memory, it must be trained each time it is used, which some will find inconvenient. The Sirius mount can also accept an auto-guider for precise tracking during long photographic exposures.

Setup and alignment

The Sirius 100ED arrived in three well-packed boxes. One box contained the telescope, a second enclosed the tripod, and a third held the equatorial mount and other accessories. By following the written instructions, I had everything together in about 30 minutes.

After plugging the mount into a 12-volt rechargeable battery, I aligned its right-ascension axis with Earth's axis. This would be a time-consuming process if not for the built-in polar-alignment scope. The polar scope's reticle comprises a set of crosshairs, a centered circle with a small offset circle denoting Polaris, and markers for the Big Dipper and Cassiopeia. Rotate the polar axis until the Dipper and Cassiopeia figures are oriented as seen in the sky, and then move the mount east-west and north-south until Polaris is centered in the small offset circle.

The reticle is illuminated whenever the mount's power is switched on, but I found it far too bright to be useful. With no way to dim the red light's level, I preferred to complete polar alignment in the dark before turning on the power.

I then proceeded to initialize the onboard computer. Because the Sirius' go-to system is not GPS-enabled, users must

THE HAND CONTROLLER for the Sirius 100ED EQ-G features full go-to capability, three alignment modes, and a database with 13,400 objects.

enter the date, time, and their location. Unlike some other non-GPS systems, the Sirius requires you to enter your observing site's longitude and latitude. Although this is the most accurate way of telling a non-GPS go-to computer where it is, it does require a bit of uncommon knowledge.

I continued the computer setup by selecting from one of three alignment modes: one-, two-, or three-star. Using one alignment star is the fastest method, but the two- and, especially, the three-star procedures are progressively more accurate.

After I performed this sequence, the computerized pointing accuracy was good enough to land each target in the field of the 26mm Plössl eyepiece. Power for the mount can come from either a 12-volt DC source or a 110-volt AC outlet with an optional adapter.

My favorite part: under the sky

Optically, the 100ED is exceptional. Star-testing showed nearly identical images on either side of focus. I saw no indication of astigmatism or spherical aberration. Instead, out-of-focus stars showed smooth, symmetrical images.

In-focus stars displayed nicely defined Airy disks surrounded by single diffraction rings. The only sign of any optical aberration was slight purple fringing around the Moon's limb and bright stars, like Sirius (Alpha [α] Canis Majoris).

The level of residual chromatic aberration in the 100ED is minor. For the average backyard astronomer using the 100ED simply to enjoy the universe, it probably would go unnoticed.

Good star-tests are one thing, but it's what observers see in-focus that really counts. Turning the scope on the night sky, I enjoyed all that late summer has to offer. And the view I had of the quadruple star Epsilon (ε) Lyrae using a 10mm (90x) eyepiece sold me on the scope's optics. Likewise, I easily resolved the challenging double star Alrischa (Alpha [α] Piscium) through both 10mm and 5mm (180x) eyepieces. I was pleasantly surprised to find images remained sharp after I added a 2.5x Barlow lens into the mix, which yielded 450x. Even at that extreme magnification, the Sirius mount proved stable. With the legs fully collapsed, vibrations dampened in less than 1 second.

Next, I visited the Hercules Cluster (M13). Although the 100ED's 3.9-inch aperture kept the cluster's 11th-magnitude individual suns dim, the scope resolved M13 into myriad points across its disk. Shifting to the Ring Nebula (M57) in Lyra, I distinguished the nebula's characteristic smoke-ring shape easily through both the 10mm and 5mm eyepieces.

I stayed up well into the morning to try my luck with some through-the-telescope prime-focus photography. The results I got of the Orion Nebula (M42), and even the difficult-to-spot Horsehead Nebula (B33), pleased me. The mount's guiding accuracy proved to be good even without an autoguider. I measured periodic error as 15".

Overall, I enjoyed my time with the Sirius 100ED EQ-G. The optics proved every bit as good as some other two-element ED apochromatic refractors costing significantly more. I'd like to see a two-speed focuser, but that's a minor point. Any refractor fan looking for high-quality optics on a budget should consider the Sirius 100ED EQ-G. It's money well-spent.

THE SIRIUS 100ED EQ-G'S CONNECTION panel features an on-off switch with indicator, slots for the hand controller and optional auto guider, and a 12-volt DC input jack. At the bottom, the polar-alignment scope protrudes from the polar axis.

BY GLENN CHAPLE

Go-to a-go-go

Decisions, decisions! You're about to purchase a telescope. Will it be a refractor or reflector? Should you place the instrument on an equatorial or alt-azimuth mount? How about the finder — an LED-powered reflex sight or a more traditional optical finder scope? No

doubt about it, when it comes to scopes, you have a lot of options.

Consider the choice between a no-frills scope or one with go-to capabilities. The former requires familiarity with the night sky so you can locate each target; the latter lets you navigate the heavens with push-button ease. When go-to telescopes were first introduced 2 decades ago, they were touted as a panacea for the novice who couldn't find sky objects with traditional scopes. Can't locate the Andromeda Galaxy? No problem! Press a button on the remote, and your go-to will get you there.

There are drawbacks to the go-to option — cost being foremost. Let's say your budget allows no more than $400 for a scope. For that money, you could pick up a quality 8-inch Dobsonian-mounted reflector. If you must have go-to technology, you'll have to settle for a smaller instrument. Usually adding to this expense is the need for batteries to power the system — typically a set of eight AAs, which will provide about 20 hours of use. This could incur an annual expenditure of $50 to $100, depending on how often you use your telescope.

If money isn't an issue, how about time? You can set up a standard telescope and begin observing after you've allowed your eyes to dark-adapt and your scope's optics to acclimate to the temperature. Not so with a go-to scope, which may take 10 to 15 minutes to initialize. This normally requires leveling the tube and pointing it north, then sighting two or three selected bright reference stars. If you live in an area where trees or buildings block stars, this process may take longer.

A third strike against go-to technology is that it isn't always user-friendly for the true novice. On several occasions, I've been asked to help a frustrated newcomer figure out how to operate a go-to scope. If you're the type who doesn't feel like spending an hour reading a manual just to program a VCR, go-to technology may not be for you.

With these warnings, you might think that I take a dim view of go-to instruments. *Au contraire!* The first time I tried a go-to scope, its capabilities wowed me. What an incredible experience to enter "M82" on the remote and watch the instrument spring to life as it sought out its quarry. To peer into the eyepiece after the scope stopped and see M82's cigar-shaped glow was nothing short of amazing! Earlier, I noted that a go-to telescope requires a 10- to 15-minute set-up time. Being able to "go to" a target in a minute or two is far more time-effective than spending 10 minutes, or longer, fumbling with sky charts and a flashlight while observing with a no-frills telescope. Cruise the heavens with a good go-to telescope, and you'll quickly become an advocate.

If money isn't an issue, and you're comfortable with technology, consider a 6- to 8-inch Dobsonian or catadioptric scope (Schmidt-Cassegrain or Maksutov-Cassegrain) with go-to capability for your purchase. Whatever you choose, just remember: A wise purchase of any telescope will enhance your enjoyment of backyard astronomy for years to come.

Questions, comments, or suggestions? E-mail me at gchaple@hotmail.com.

Next month: We'll take a look at finder scopes. Clear skies!

GO-TO INSTRUMENTS, such as these entry-level models, are for beginners who aren't familiar with the night sky. However, consider your patience with operating technical equipment prior to purchasing one. *ASTRONOMY:* JIM FORBES

JMI – BRILLIANT SOLUTIONS FOR YOUR ASTRONOMICAL NEEDS!

BRILLIANT NEW PRODUCTS FOR LIGHTBRIDGE

Shroud
Computer
MOTOFOCUS
Wheeley Bars

NEW FOR CELESTRON
Piggy-back camera mount
Computer holder
Carrying case
MOTOFOCUS

Order Now! 1-800-247-0304
Visa & Mastercard accepted.

JMI Telescopes - Jim's Mobile, Inc. - 8550 W 14th Ave - Lakewood, CO 80215 - U.S.A.
Info 303-233-5353 - Fax 303-233-5359 - Orders 800-247-0304 - info@jmitelescopes.com

Delivering the Best!

PREMIER SELECT CELESTRON DEALER

optcorp.com
800.483.6287

Whatever the symptoms are, the good doctors at OPT have the cure. Celestron telescopes and accessories are always the right prescription.

Craig Weatherwax, "Universologist" & Founder of OPT.

OPT Oceanside Photo & Telescope
918 Mission Avenue • Oceanside, CA 92054

riverscamera.com

MEADE Accessory Headquarters

- **DEEP SKY IMAGER II $599.95** Phone or Web Free Shipping
- **SERIES 5000 Ultra Wide Angle Eyepiece** In Stock /Free Shipping
- **NEW Meade LX200R's** In Stock
- **We know MEADE RCX Telescopes.** Factory-trained staff members. Call Us!

Vixen Optics Premier Dealer See our website for details

TeleVue® Factory Authorized DEALER All TeleVue Eyepieces in stock

Scope Armor protective covers for telescopes

CELESTRON®

New SkyAlign Alignment Technology Fast, easy alignment. Simply choose three bright stars. Telescope does the rest. CPC800 $1899.00 + $95 s+h.

NEW! Celestron SkyScout Revolutionary handheld device, GPS technology. Point and click to instantly identify stars & planets visible to naked eye. Includes audio/text facts & trivia about our most popular celestial objects. **SkyScout Personal Planetarium** $399.00 + s+h.

Nikon • Canon • Pentax • Sony • Leica
Olympus • Kowa • Bushnell • Kendrick
JMI Accessories • ScopeTronix Accessories
Telrad • Losmandy • Vixen Products
Coronado • Large Book Selection

- One of the Largest Binocular and Telescope Displays in the East
- Mail-Order or In-Store • No Sales Tax!
- Used Scopes — Buy, Sell or Trade-In
- Knowledgeable, Personalized Service

M-W 8:30-6 Th. 8:30-7 Fri. 8:30-6 Sat. 9:30-5

Rivers CAMERA AND TELESCOPE
Toll-Free (800) 245-7963
www.riverscamera.com
454 Central Ave., Dover, NH 03820 Fax: (603) 742-5456
FREE Shipping: on items 15 lbs. or less in the lower 48 states

MONEY BACK 100% Satisfaction GUARANTEE

BIG EVENT:
RIVERS ASTRODAY
April 7, 2007
Seminars, Specials, Factory Reps.
See website for details.

New! Product Showcase

This new online section highlights the latest and best astronomy products.

Thinking about purchasing something ***ASTRONOMICAL*** *for yourself or someone special?*

First, check out our product showcase at...
www.astronomy.com/products

Read about telescopes, accessories, software, and more before you buy.

Photos and detailed descriptions give you the inside scoop on the best celestial gear.

Astronomy.com

CIR-ADH-06X1420RH

BY PHIL HARRINGTON

The Lion's roar

For the past 6,000 years, Leo the Lion's form has stalked the spring sky. One of the oldest constellations, Leo traces its origin to ancient Mesopotamia. Then, as now, stargazers imagined the constellation's hook-shaped "sickle" of stars as a Lion's head, and a triangle of stars to their east as its haunches. Leo appears crouched, ready to pounce on unsuspecting prey.

Beckoning our attention to Leo in the first place is the sky's 21st brightest star, **Regulus**, which marks the lion's heart. Take a look at Regulus through your binoculars on the next clear night. It's hard to believe that sparkling star is actually spinning so rapidly its disk is distended into an egg shape. Using instruments atop Mount Wilson in California in 2004, Harold McAlister of Georgia State University and his colleagues found that Regulus' equatorial diameter is about ⅓ greater than its polar width. That's quite a midriff bulge!

A careful look with 12x or higher binoculars may show Regulus' 8th-magnitude companion sun nearly 3′ to the west-northwest. Although the stars are widely separated, Regulus' glare often consumes the companion. You'll need a steady hand (or better yet, a tripod) to hold your binoculars still enough to glimpse it. If that proves too tough, pure white Regulus also forms an easy binocular pair with golden 31 Leonis to its south. These two aren't a true couple, however, but just a chance, line-of-sight pairing.

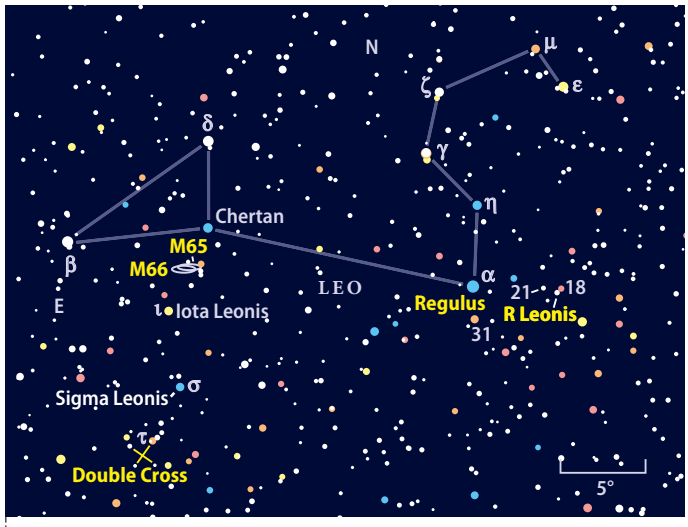
One of spring's best variable stars lies about 5° from Regulus. Known as **R Leonis**, this red giant physically expands and contracts over the course of 310 days. As the star pulses, its brightness cycles between magnitudes 5.8 and 10.0 and back. R Leo is coming off maximum brightness in February, which means it should still be around 7th magnitude now. Look for its ruddy glint south of the 6.5-magnitude star 19 Leonis. The stars 19, 18, and 21 Leonis form a distinctive triangle that points right at R Leo.

None of those three stars fluctuates in brightness, and so they serve as useful comparison stars for judging R Leo's magnitude. To learn how to estimate a variable star's brightness, read this column's online extra at www.astronomy.com/toc, and we'll walk through the process together. There's also a finder chart there for R Leonis that shows more comparison stars.

Let's now shift our attention to eastern Leo. Being far from the Milky Way's plane, the Lion can't boast of beautiful star clusters, rich star fields, or glowing nebulosity. But it can flaunt five galaxies from the Messier catalog. The two brightest, **M65** and **M66**, are found southeast of the star **Chertan** (Theta [θ] Leonis), which marks the right angle in the triangle of stars forming Leo's back and tail. To find them, drop about half a binocular field (2.5°) south of Chertan to a line of three 7th-magnitude stars. Now, look very carefully about half a field to their east for a very dim smudge of light lying below a faint star. That's M66. M65 is just west of M66, but, at half a magnitude fainter, is much more challenging. You'll probably need to brace your binoculars in order to make them out. I can routinely see M66 through my 10x50s from my suburban New York backyard, but M65 takes a better-than-average night.

Finally, follow a zigzag line south of Chertan, past the stars Iota and Sigma Leonis to a small four-star arc that hooks to the southeast. The brightest star in the arc, 4th-magnitude Tau (τ) Leonis, teams with a fainter point to its southeast to create a pretty double star through binoculars. Place Tau toward the upper right (northwest) corner of your field, and carefully look around. You should spot three more faint doubles. Add them together, and you get an asterism that I like to call the **Double Cross**, because all four pairs collectively fall into an X pattern. None of the four pairs is a true physical binary, however, because all eight stars are located at very different distances. But that doesn't detract from their unique appearance through our binoculars.

Next month, we'll use two dogs to hunt more spring targets. Until then, remember that two eyes are better than one.



LEO THE LION offers springtime binocular targets ranging from dynamic variable stars to Messier galaxies. *ASTRONOMY*: ROEN KELLY

ONLINE EXTRA Learn how to estimate the brightness of variable stars at www.astronomy.com/toc.

Just what the Doctor ordered!

Delivering the best telescopes and accessories at the best prices since 1980.

The best prescription for your celestial maladies is to see the doctors at OPT. With over 27 years of experience, we can provide the cure for your astronomy needs.

Craig Weatherwax, "Universologist" & Founder of OPT.

We have all the big names:

MEADE
Telescopes for the serious astronomer!

CELESTRON
Astronomy made easier!

PENTAX
Imagine the difference!

SBIG · SB Software Bisque · TAKAHASHI · TeleVue Visionary

...and many MORE!

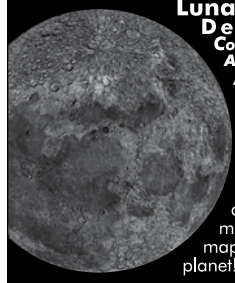
optcorp.com

For Binoculars visit www.optbinoculars.com

OPT
Oceanside Photo & Telescope • 800.483.6287
918 Mission Avenue • Oceanside, CA 92054

Navigate the Moon, Mars and Earth...

Precision mapping software for Windows™ with 3D terrain modeling & visualization

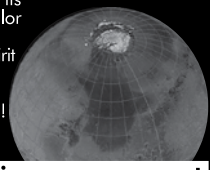


Lunar Map Pro 5.0 Deluxe Edition
Comprehensive 360° Atlas & Tools for Advanced Lunar Study
With twice the resolution of other lunar software products, unparalleled flexibility in map viewing options, and exclusive 3D – the most advanced lunar mapping software on the planet! Only **$89.95**

Plus... **Lunar Map Pro Essentials Edition** Streamlined to eliminate the most resource-intensive features; perfect for field use and older computers! Only **$35**

Celestial Explorer: EARTH View Earth from any point in space, investigate topographic features in detail, visualize the planet's surface in 3D, learn about world geography, and much more. Only **$29.95**

Celestial Explorer: MARS
With1400+ features in its database and hi-res color maps (both image & geology)—see where Spirit & Opportunity landed, experience the Martian terrain in 3D, and more! Only **$45**



Order online now at
www.riti.com
Or contact RITI: tel 781-942-1655
P.O. Box 418, Reading MA 01867

DISCOVER
Kitt Peak
National Observatory
Tucson, AZ

Public Programs for Amateur Astronomers

- *CCD Workshops*
- *Digital camera imaging*
- *CCD Imaging with our expert guides*
- *Astrophotography*
- *or just observe*

520-318-8726
www.noao.edu

SKYSCAN LIGHTNING/STORM DETECTOR

Xtreme Research Corporation
Port Richey, Florida

The portable, handheld SkyScan detects electromagnetic emissions from lightning strikes and thunderstorm activity within 40 miles (64 kilometers) of your location. An audible warning tone sounds when it detects a lightning strike.

Price: $239.95
[t] 888.732.0665
[w] www.xgun.com

MICRO-SLEW AXIS MOTORS FOR VIXEN PORTA MOUNT

JMI Telescopes
Lakewood, Colorado

A JMI dual-control hand unit controls two motors for smooth, three-speed slewing of the Vixen Porta Mount. The two motors slew independently and are easy to install. The hand controller requires a 9-volt alkaline battery.

Price: $199.95
[t] 800.247.0304
[w] www.jmitelescopes.com

ZENITHSTAR 66 SD DOUBLET APO REFRACTOR

William Optics Corporation
Cypress, California

This portable f/5.9 refractor has a 2½-inch (66 millimeters) aperture, a 15-inch (388mm) focal length, and 1.78" resolving power. Features include a retractable lens shade, a Crayford focuser, a 2" SCT dielectric mirror diagonal, and a 15" by 9.6" by 6.5" (38.5 cm by 24.5 cm by 16.5 cm) aluminum carrying case.

Price: $448
[t] 866.918.6888
[w] www.william-optics.com

SKYNYX2-2 CCD CAMERA

Lumenera Corporation
Ottawa, Ontario

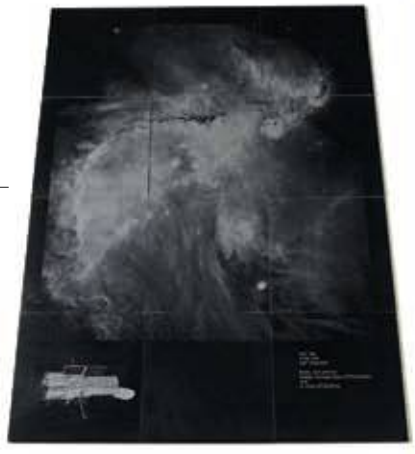
Based on the company's scientific microscopy camera technology, this USB 2.0 charge-coupled device (CCD) for astroimaging provides 2-megapixel (1,616 by 1,232) resolution at 12 frames per second.

Price: $2,295
[t] 613.736.4077
[w] www.lumenera.com

COSMIC LASER ETCHING

Lake Michigan Tile, LLC
Coloma, Michigan

Laser etching brings the beauty of the cosmos into your home. Striking astronomical images of any size — as large as a wall-covering mural, or as small as floor-tile-sized medallions — can be laser-etched onto marble, glass, or granite.



Price: $80 to $175 per square foot
[t] 269.876.1208
[w] www.lakemichigantile.com

SPACE STATION SIM PC GAME

Vision Videogames, LLC
Joppa, Maryland

Developed in collaboration with NASA, the *Space Station Sim* PC game allows users to build and manage a unique simulated version of the International Space Station. This game also lets you create and care for ISS astronauts and crew members.

Price: $19.99
[t] 410.825.1200
[w] www.enlight.com

HomeDome/ProDome

PD15 in New Jersey

- True Rotating Dome
- Easy Assembly
- 6, 10, 15ft. Diameter
- All Fiberglass
- Motors & Automation
- Wide Slot Openings
- Complete Systems Priced from $2990

ROBOFOCUS™
Automated Focus Driver with temperature compensation
$425

Technical Innovations, Inc.
7851 Cessna Ave.
Gaithersburg, MD 20879
Ph: 301-977-9000 • Fax: 301-977-1106

FREE BROCHURE
www.homedome.com • www.robofocus.com

Woodland Hills Telescopes

Order: Mon-Sat • 9-6 PT
Toll Free: 888.427.8766
P: 818.347.2270
F: 818.992.4486
WHtelescopes.com

5348 Topanga Canyon Blvd.
Woodland Hills, CA 91364

MEADE

ETX | LX90 GPS | RCX | LX200 GPS

CELESTRON

CGE | Nexstar GPS | Nexstar 8i SE | CPC

CORONADO

We now have the new Personal Solar Telescope, P.S.T.-CaK, in our store. It allows you to see and photograph solar flares and prominences safely. **$499**

P.S.T.-CaK

The MAXSCOPE 40 Telescope with BF10 – New Low Price **$1699**

LOSMANDY

- New Gemini goto in stock
- G11 Mount with dual axis drive
- GM-8 mount, dual axis drive

Mount

TeleVue Visionary

Eyepieces with FREE SHIPPING!

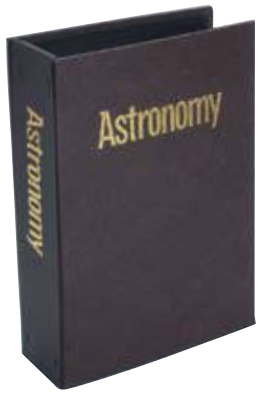
Plossl 8, 11, 15mm.....$85
20, 25mm.....$99
32, 40mm.....$119
55mm.....$235
Radian 3, 4, 5, 6, 8, 10, 12, 14, 18.0mm.....$250
Zoom Nagler 2-4mm.....$395
3-6mm.....$385
Click 8-24mm click stop.....$215

Panoptic 41mm.....$510
35mm.....$380 27mm.....$345
24mm.....$310 22mm.....$285
19mm.....$245 15mm.....$215
Nagler Type 5 31mm.....$640
20mm.....$450 16mm.....$330
Nagler Type 4 12mm.....$365
17mm.....$395 22mm.....$480
Nagler Type 6 13, 11, 9, 7.5, 3.5 and 2.5mm.....$290
Zoom Dioptrix 8-24mm.....$240

Canon KNOW HOW™ Cameras, Binoculars
CELESTRON
Denkmeier
JMI
MEADE
MoonLite Telescope Accessories
ORION
SBIG ASTRONOMICAL INSTRUMENTS
SB Software Bisque
Starry Night
StellaCam
TAKAHASHI
Vixen
William Optics

WIN A FREE TELESCOPE! ENTER AT www.whtelescopes.com

PROTECT YOUR INVESTMENT!



Preserve your library of *Astronomy* magazines with durable hardcover binders.

ITEM NO. 14007
1 for $13.95 • 3 for $38.95
5 for $59.95

Order yours today!

TO ORDER BY MAIL: Send your order to Kalmbach Publishing Co., Dept. A2002, 21027 Crossroads Circle, P.O. Box 986, Waukesha, WI 53187-0986. Use chart below for shipping & handling charges.

MERCHANDISE TOTAL	ADD
$15.00 or less	$4.95
$15.01–$30.00	$5.50
$30.01–$50.00	$6.50
$50.01–$75.00	$7.50
Over $75.00	$8.50

Canada add an additional $2.00, other foreign add an additional $5.00. For Wisconsin delivery, add 5% sales tax to total; for Pennsylvania delivery, add 6% sales tax to total. For delivery in Canada add 7% GST to total. Payable in U.S. funds. Checks must be drawn on a U.S. bank except for those from Canada; GST included. Make checks payable to Kalmbach Publishing Co. Prices and availability subject to change.

call 1-800-533-6644
Mon–Fri, 8:30am–5:00pm Central Time.
Outside the U.S. and Canada, call 262-796-8776.
Please have your credit card ready.

fax 262-796-1615

www astromagbooks.com
Secure online ordering available.

Astronomy

A30785AD A2002

NEXT MONTH
in the May issue

NASA/ESA/STScI

Astronomy
The world's best-selling astronomy magazine

5 things you need to know
Troubled by Hubble's law? Perplexed by the Big Bang? Tune up your cosmic knowledge with answers to cosmology's big questions.

Making 20 million galaxies
Astronomers transformed 25 terabytes of data into virtual galaxies to investigate cosmic evolution.

Seeing the red limit
Find out how astronomers measure distances in the cosmos.

The great comet of 2007
Observers around the world got spectacular views of the brightest comet in 40 years.

All about M13
Globular star clusters like the Hercules Cluster helped astronomers refine our galaxy's structure.

Avoid the astronomy blues
Many beginners become discouraged after a short time — here's how to avoid that trap.

Deep-sky-object hunter
Meade's 10-inch LightBridge scope will help you see faint details in distant targets.

SUBSCRIBE TODAY!
1.800.533.6644
ORDER ONLINE AT
Astronomy.com

APRIL 21

Bringing astronomy to the people

Astronomy Day is a worldwide campaign that allows astronomical organizations to share their passion for astronomy with the public. *Astronomy* will again team up with Meade Instruments Corporation to celebrate the day with observatories, science centers,

ASTRONOMY DAY GATHERINGS often feature activities for children. The Adler Planetarium's 2004 celebration in Chicago allowed visitors to create a "comet" from dry ice and ordinary household items. ADLER PLANETARIUM AND ASTRONOMY MUSEUM

planetaria, and museums across the United States. These participating organizations will each receive a Meade telescope to raffle and copies of *Astronomy* magazine to give away. To read more about these events, visit www.astronomy.com/astronomyday.

To find Astronomy Day gatherings in your area, contact local astronomy clubs, museums, science centers, observatories, or planetaria. For further listings, or to post your group's event, visit our online calendar at www.astronomy.com/events.

APRIL 6
Far Out Friday
Adler Planetarium and Astronomy Museum, Chicago. ☎ 312.922.7827; ✉ guestservices@adlerplanetarium.org; 💻 www.adlerplanetarium.org.

APRIL 11–14
Mid-South Star Gaze
Rainwater Observatory and Planetarium, French Camp, Mississippi. ☎ 662.547.6377; 💻 www.rainwaterobservatory.org/stargaze/index.htm.

APRIL 13–15
Delmarva Stargazers Club Star Gaze
Tuckahoe State Park, Queen Anne, Maryland. ✉ don.surles@verizon.net; 💻 www.delmarvastargazers.org.

APRIL 13–15
South Pacific Star Party
Wiruna, near Ilford, New South Wales, Australia. 💻 www.asnsw.com/spsp.

APRIL 17–22
Southern New Mexico Star Party
City of Rocks State Park, near Faywood, New Mexico. ☎ 505.527.8386; ✉ jgilkiso@wildblue.net; 💻 www.astro-npo.org.

APRIL 19–22
Georgia Sky View
Indian Springs State Park, Jackson, Georgia. 💻 www.flintriverastronomy.org.

APRIL 20–22
South Jersey Spring Star Party
Belleplain State Forest, near Woodbine, New Jersey. 💻 members.aol.com/sjastroc.

APRIL 21
Astro Day 2K7
Prince Kuhio Plaza, Hilo, Hawaii. 💻 www.astroday.net.

APRIL 21
Brazosport Astronomy Day
Brazosport Planetarium, Chute, Texas. ✉ tcas@bcfas.org; 💻 www.bcfas.org.

APRIL 27–29
Southern Star Astronomical Conference
Wild Acres Retreat, Little Switzerland, North Carolina. 💻 charlotteastronomers.org/southernstar. 🅰

CONTACT INFORMATION

Please submit club announcements 5 months in advance to Coming Events, *Astronomy*, P. O. Box 1612, Waukesha, WI 53187, or kneubauer@astronomy.com. Also use this e-mail address to submit your events for our online calendar.

INDEX *of* ADVERTISERS

50 Greatest Mysteries of the Universe 11
Abbeville Telescope Company 85
Adorama 61, 69
Anttler Optics 85
Ash Manufacturing 83
Astro Haven 85
Astro-Physics 83
AstroGizmos 82, 84
Astronomics 52-53
Astronomy.com 75
Astronomy Delight 85
Astronomy magazine 80
Astronomy magazine binders 79
Astronomy magazine Tour 60
Astronomy Technologies 84
Astrozap 81
Atomic Time 69
Backyard Observatories 85
Beam of Light Technologies 82
Beta Electronics 84
Bethany Sciences 84
Big Bang Astronomy Shop 82
Binoculars.com 83
Celestron 90
Denkmeier Optical 83
Discovery Sky's Resort 81
Efstonscience, Inc 81, 83
Equatorial Platforms 82
Flo USA, Inc 84
Focus Camera 81, 85
Glatter Howard 82
Into the Wind-The Kite Source 82
Jim's Mobile Inc 75
Khan Scope Centre 81
Kitt Peak National Observatory 77
Lake Michigan Tile 84
Let's Talk Stars 81
Luckyduck.com 82
Lumicon 60
Max Factory 83
Meade Instruments Corporation 2, 3, 7
Moonlite Telescope Accessories 84
Northeast Astronomy Forum 69
Novaspace 84
Oceanside Photo & Telescope 75, 77
Orb Publishing 82
Orion Telescopes & Binoculars 68, 89
Owl Services 81
Parks Optical 13
Pegasus Optics 82
Rainbow Symphony 85
RITI 77
Ritz Camera Superstores 85
Rivers Camera Shop 75
Scope Armor 82
Scope Buggy 83
Scope City 17
ScopeStuff 85
SCS Astro 82
Shutan Camera & Video 81
Smartastronomy.com 83
Software Bisque Inc 20, 21
Solarscope 84
Southeastern Camera & Telescope 82
Stargazers Inn 84
Stellarvue 84
Technical Innovations 79
Telegizmos 82
Tele Vue Optics, Inc 16
The Teaching Company 25
Travel Quest 83
Used Telescope Buyer 85
Vixen Optics 23
Wicked Lasers 84
William Optics Co 17
Woodland Hills Photo Images 79
www.bigbinoculars.com 84

Web Site Directory

Check out these businesses... They're only a click away!

ASTROZAP
astrozap@yahoo.com
www.astrozap.com
Your #1 source of dew prevention shields on the planet. Hundreds in stock! Dew it in style!

DISCOVERY SKY'S
California Bay area Resort Obsersvatory 14" Meade LX 200 DSI ccdcam roll off roof observatory luxurious 4 BR water front home clear sky's
www.vrbo.com/93091

EFSTONSCIENCE
sales@telescopes.ca
www.telescopes.ca
Science & Astronomy SuperStore since 1970. Canada's best prices selection and staff.

FOCUS CAMERA & VIDEO
www.FocusCamera.biz
Thousands of telescopes, eyepieces, accessories, binoculars, digital photography, & consumer electronics.
1-877-883-5937

KHAN SCOPE CENTRE
info@khanscope.com
www.khanscope.com
Serving Canada & U.S. for over 19 years
Toll Free: 1-800-580-7160
Telescopes & Accessories at Discount Prices

OWL SERVICES
owl1@owlservices.com
www.owlastronomy.com
Special prices on Knight Owl Eyepieces Telescopes • Binoculars!
FREE # 1-888-OWL-WARE
10-6 EST M-F

SHUTAN CAMERA
Family Owned for 88 Years!
www.shutan.com
Located in Vernon Hills, IL. Large selection of astronomy & camera accessories. We carry Meade, Celestron, Televue, Nikon, Canon, and other brands. TOLL-FREE 866-621-6363

STARIZONA
Let's Talk Stars
www.letstalkstars.com
With your Hosts David and Wendee Levy
Astronomy talk radio

MARKETPLACE

TeleGizmos.com
Telescope Covers
Quality, Dependability, Value...
starting at only $29.00
Available at many fine dealers
972-849-9240 www.telegizmos.com

New Concepts in Gravitation
www.physicsessays.com
Volume 18 Number 1 pages 37-49

Scope Armor Covers: starting at $39.95
The first line of defense for your telescope!
SCOPE ARMOR™

- Repel water
- Repel heat
- Resist scratches & dents
- Easy installation • Affordable
- Fit most Schmidt-Cassegrain scopes
- Made of durable marine/military grade materials

For details visit
www.scopearmor.com
or call **603-743-4083**
Dealers welcome
Major Credit Cards Accepted

PEGASUS OPTICS - *Mirrors*
★ Wavefront P-V <1/8 wave ★ 1.6 -2" thick ★IAD Coating

Dia.	FL	Price	Dia.	FL	Price
18"	75.6"	$2800	22"	100"	$5000
20"	90"	$3600	24"	110"	$6600

"You'll see the difference"
Web Site: PegasusOptics.Com E-mail: hallj@satx.rr.com
TEL: (210) 267-9937

Don't let your arms get tired holding your binoculars
Get Your EZ GAZER Today!
The New Binocular Star Gazing Chair
ASTRO GIZMOS
JGS Enterprises, LLC
"We're Looking Beyond"
www.astrogizmos.com
1-540-898-0636

www.z-bolt.com

Green Lasers for
Star Pointing
Star Finders
Scope Mounting
- **Shop 20+ Green Laser Models**
- **Remote Switches for Scope Mounts**
- **Universal Laser Mount Brackets**
- **Astronomy Laser Gift Packs!!**
- **Personalize with laser engraving**
- **APC Computerized Power Output**

All major credit cards accepted; faxed PO's from universities, corporations, government agencies, and the US Armed Forces.

Beam of Light Technologies, Inc.
Toll Free: 877-801-9299
Fax: 603-309-6020

Howie Glatter Introduces:
The Blug® (Barlowed collimation plug)
for Newtonian primary adjustment

Fits most drawtubes to perform ultra-visible Barlowed collimation, using any well-centered single-beam laser collimator
"This is what everybody has been waiting for!"
Dave Bonandrini
Cloudy Nights
and AstroMart
Blug review
Patent Pending
"...I had to have one."
Tom Trusock
Cloudy Nights NEAF 2006 report
Howie Glatter's Full Line Astronomical Collimators, SkyPointers and Brackets on the Web
Howie Glatter 3850 Sedgwick Ave #14F
Bronx, NY 10463 Tel/Fax (718) 796-3203
www.skypointer.net www.collimator.com
e-mail: howieglatter@mindspring.com

Kites & Wind Art
Have fun anywhere the wind blows.
FREE color catalog with hundred of kites, flags, windsocks and spinners.
Fast, friendly service since 1980.
www.IntoTheWind.com
1408-A Pearl St., Boulder, CO 80302 • (800) 541-0314

TRACKING for DOBS
* High power observing and group viewing
*Astro-imaging with NO field rotation
call write or e-mail for free brochure
EQUATORIAL PLATFORMS 530-274-9113
15736 McQuiston Lane Grass Valley CA 95945
tomosy@nccn.net www.equatorialplatforms.com

Starry Night PRO

BIG BANG ASTRONOMY SHOP
We're Always Expanding!
Authorized Dealer:
Meade, Celestron, Orion, Lumicon, JMI, Astrozap
Raleigh, North Carolina
866-352-2264
Home of the Quick Connect • A Time/Cost Saving Telescope
www.BigBangAstro.com

EUROPE'S PREMIER WEBSITE
http://www.scsastro.co.uk
SCS ASTRO

The ONLY Green Laser Designed Specifically for Astronomy!
Now with easy-aim telescope mount!
- Easily mounts to any telescope
- Can run for hours
- Designed to operate in cool weather
- 4 other models to choose from

Thousands sold—fast delivery & we ship worldwide.
Visit www.LuckyDuck.com/astronomymag or call toll-free **877-388-7362** for your special Astronomy Magazine discount.

(Shown here with one of several available telescope mounts—beam is simulated)
Jasper *The next generation green laser.*

ASTRO-PHYSICS
Experience the ultimate in quality instruments for discriminating observers and astrophotographers.
Telescopes, Go-To German Equatorials, Visual and Photographic Accessories
Unparalleled Service and Support
Experience the legend that is
ASTRO-PHYSICS!

11250 Forest Hills Road
Machesney Park, IL 61115, USA
Ph: 815-282-1513, Fax: 815-282-9847
www.astro-physics.com

866.340.4578
DENKMEIER.COM
Binoviewers & Optical Accessories
INNOVATIONS TO FOLLOW THE STARS

Telescopes.com
UP TO 50% off retail!
World's Largest Selection of Telescopes!
www.telescopes.com 1-800-303-5873

SmartAstronomy.com
The Largest booth for Astronomical Discounts!
North East Astronomy Forum
NEAF '07
Meade-Coronado Telescopes
Hundreds of Accessories
888.291.6577

ScopeBuggy
• For use with most tripods, DOBs and piers
• 10" Pneumatic tires for soft ride
$265.00
Plus S&H
Approx. $30 Shipping USA

SCOPEBUGGY
P.O. BOX 834
Elephant Butte, NM
87935
Toll Free: 866-312-8449
www.scopebuggy.com

Total Solar Eclipse 2008

You choose the destination for
2 Minutes of Totality!
The Ancient Silk Road aboard the China Orient Express
Arctic Voyage to the North Pole
Great Cities of Russia and the Grand Passage Through Siberia
TravelQuest
Make your reservations today!
tq-international.com 800-830-1998

We Challenge You to...
PC & MAC CD-ROM
TRUE INTERACTIVITY

MASTER AUTOSTAR®
Get it Right Before Going Out
www.maxfactory.com
Master Autostar... ALL of it!
www.maxfactory.com

For great deals, look North

We carry the complete line of SkyWatcher telescopes. Easy shipping to the U.S. & Canada
EfstonScience is Canada's #1 science and astronomy equipment dealer. Our knowledgeable staff of astronomy enthusiasts keeps our 8000 ft.² retail SuperStore jam-packed with the all the latest in hot scopes and accessories. And it is all online — shop for 1000's of products on our website at www.telescopes.ca. With great prices and easy shipping across North America, discover for yourself why EfstonScience has been Canada's brightest star for over 36 years, eh.
FEATURED BRANDS
• Meade • TeleVue
• Lumicon • Vixen
• Celestron • Pentax
• Thousand Oaks • Orion
NEW & USED EQUIPMENT
EfstonScience 36th ANNIVERSARY 1970 - 2006
Proudly Canadian
EfstonScience
The Science & Astronomy SuperStore
3350 Dufferin Street, Toronto, ON, Canada M6A 3A4
(416) 787-4581 (888) 777-5255 www.telescopes.ca

FOCUS ON
NORTHERN OKLAHOMA COLLEGE OBSERVATORY
Enid, Oklahoma
The Ash-Dome pictured is our 16'6" diameter unit. Housed is a 14-inch Schmidt-Cassegrain telescope equipped with a CCD camera and spectrograph. Students enrolled in astronomy are able to conduct research. The Astronomy Department encourages local students of all ages and astronomers in the community to collaborate with undergraduate students. The NOC Observatory has hosted over 800 visitors over this past academic year.
ASH MANUFACTURING COMPANY
P.O. Box 312
Plainfield, IL USA 60544
815.436.9403 • FAX 815.436.1032
web site: www.ashdome.com
email: ashdome@ameritech.net
ASH DOME
ASH-DOME is recognized internationally by major astronomical groups, amateurs, universities, colleges secondary & primary schools for their performance durability and dependability. Manual or electrically operated units in sizes from 8 to 30 feet in diameter; sensibly priced. Brochures and specifications available.

MARKETPLACE

bigbinoculars.com
Astronomical binoculars (50-150mm) and accessories at down-to-earth prices.
Toll free- 866-244-2460 (BIG-BIN0)
www.bigbinoculars.com
OBERWERK FUJINON

StarGazers Inn & Observatory
Nightly StarGazing in Private Observatory
Luxury B&B in Big Bear Lake, CA Offers Romance Under the Stars! Queen Featherbeds, Fireplaces, Candlelit Spa Tubs, Indoor Heated Pool, Sauna, Game Room, & More!
866-482-STAR (7827) www.stargazersinn.com
- Mention this ad for discount -

Cosmic Laser Etching
Experience the power of light on granite and marble
Visit our Web site
www.LakeMichiganTile.com

DISCOVER THE SUN...
847-579-0025
www.solarscope.com

Wicked Laser Pointers
Green, Red, and Blue Laser Pointers
Enough power to pop balloons, ignite matches, and light cigarettes!
Order online at: www.wickedlasers.com

SPACEFEST
•astronauts •space art •auction
•speakers •exhibits •vendors
PHOENIX-MESA • 2007
www.spacefest.info

Green Laser Pointer
points out the stars
www.betapointer.com
phone 800.546.2382

METEORITES
Museum-Quality collectors' specimens. Meteorite jewelry, books, unique gift items. Authenticity guaranteed.
Color Catalog $3 USA, Canada and Mexico $6 Foreign Refundable with order.
The Universe Collection
P.O. Box 3726-A, New Haven, CT 06525-0726
203 393-3395 fax 203 393-2457
www.universecollection.com
VISA • MC • AMEX

Dielectric.
Quartz.
1/10th wave.
$189.95
Guaranteed!
Each Astro-Tech quartz dialectric 2" mirror diagonal comes with its own Zygo interferogram showing its 1/10th wave or better surface accuracy – *after being coated!*
The premium Astro-Tech diagonals have durable 99% reflectivity *46-layer dielectric* first surface mirror coatings, a non-marring brass compression ring 2" eyepiece holder, a 1.25" compression ring eyepiece adapter, and your choice of either a standard 2" nose piece for refractor use at $189.95 (shown above) or a threaded ring to connect to a Schmidt-Cassegrain rear cell at $199.95.
ASTRO-TECH
from Astronomy Technologies
Astro-Tech is available at these U. S. dealers:
astronomics.com • highpointscientific.com
blueplanetoptics.com • auroraastro.com
In Europe, Astro-Tech is available at:
aleph-lab.com • locascope.com
http://home.planet.nl/~lefeb019/

Introducing the...
NEW Astro Gazer
Portable Observatory
* Aluminum & PVC Frame Construction
* Weatherproof, Light Blocking Material
* Full 360° Rotation
* 10' Diameter, 8.5' High
* 1/2 Hour Assembly, No Tools Required
* Stores in Easy Carry Bags
* Fits Easily in the Car
* In Stock, Ready to Ship!
JGS Enterprises, LLC
"We're Looking Beyond"
Home of Astro Gizmos
www.astrogizmos.com 1-540-898-0636

MoonLite Telescope Accessories
2" Refractor focusers
Large format Refractor focusers
SCT focusers
Motor focus dual rate auto brake hi-knob, shaft lock compression ring pc interface high res stepper motor custom anodized color 100% made in USA
Newtonian focusers
www.focuser.com
570-275-7935

SEIZE THE NIGHT!
SV90T FLUORITE APO TRIPLET
Exceptional
TOP RATED* SV4 APO TRIPLET
*Review in Astronomy Magazine by Phil Harrington
STELLARVUE®
SEEING IS BELIEVING
WWW.STELLARVUE.COM
(530) 823-7796

SOLAR ECLIPSE 2008 TOURS
CHINA www.SolarEclipseChina.com
RUSSIA www.SolarEclipseRussia.com
MONGOLIA www.SolarEclipseMongolia.com
FLO USA
For more information, please call:
1-888-435-6872

Sell Your Used Telescope

We Pay Top Dollar For:

- Schmidt Cassegrain
- Dobsonian
- Newtonian
- Refractor
- Reflector
- CCD's
- Tripods
- Scopes
- Cases
- And More!

used telescope buyer

Free Price Quotes:
866-735-5444 ext. 9
www.UsedTelescopeBuyer.com

ScopeStuff

Telescope Accessories & Hardware
www.scopestuff.com
512-259-9778

WOLFCAMERA

OUR EXPERTISE IS FREE!

EXPERTISE: Chuck Pisa, our staff astronomer, has 20 years experience recommending optical instruments to amateurs and professionals at our Sarasota location. You can e-mail questions to Chuck at cpisa@mindspring.com

SELECTION: We have a HUGE selection of products from telescopes, binoculars and CCD cameras to filters and eyepieces. If it's astronomy-related, we have it! We carry Meade, Celestron, TeleVue, and Apogee as well as a selection of used telescopes.

SARASOTA, FL
2069 Siesta Drive
(941) 955-3537 • (941) 366-8640 fax

ECLIPSE SHADES™

Safe Solar Viewers
Custom Imprinting Available

The ultimate in protection from harmful solar radiation. Lenses are made of our exclusive scratch resistant optical density 5 "Black Polymer" material. Eclipse Shades filter out 100% of harmful ultra-violet, 100% of harmful infrared, and 99.999% of intense visible light. These premium filters create a sharper ORANGE colored image of the sun.

Rainbow Symphony, Inc.
6860 Canby Ave. #120, Reseda, CA 91335
(818) 708-8400 • Fax (818) 708-8470
eclipse@rainbowsymphony.com
www.rainbowsymphony.com/soleclipse.html

ASTRO HAVEN

Non-Rotating Clamshell Domes

- 7', 12', 16', or 20' Diameter
- Low Maintenance
- Fast Erection
- Low Cost

Full 180° Viewing Radius

#120-1675 Martin Drive, Surrey
British Columbia, Canada V4A 6E2
www.astrohaven.com *e-mail: domesales@astrohaven.com*

Phone (604) 536-3614
Fax (604) 536-8953

Can you imagine...

AstronomyDelight!
and
Learning Delight!
Nationwide franchise opportunities available

Enormous untapped markets with unlimited profit potential
Virtually no overhead - No royalties
Full equipment setup - Veterans discounts
Work your own schedule
Income range well over $100 - $500 per hour!
Even the ability to sell quality telescopes from premiere manufacturers!

LIMITED OFFERING! **$9,500.00!**

Astronomy Delight!™
www.astronomydelight.com
845-229-5572
TeleVue Visionary

Backyard Observatories

www.backyardobservatories.com

Roll off roof observatories
Sirius Observatories domes
Installs, piers, roof motors, plans, kits, and other observatory accessories.
Backyard Observatories 330-667-3214
8411 Rodgers Rd., Lodi, OH 44254

So Many Ads. . ., How Does One Choose?

ONE-STOP SHOPPING

For All Of Your Astronomy, Digital Photography and Consumer Electronics Needs

focus CAMERA & VIDEO

MEADE • LEICA
CELESTRON
TELEVUE • CANON
BUSHNELL • ZEISS

HQ for SONY Alpha DSLR System

SONY α
like.no.other

SERVING CUSTOMERS HONESTLY SINCE 1966

TOLL-FREE
877.883.5937
www.focuscamera.biz

Abbeville Telescope Company

We're Focused on the best

ATC makes choosing the right equipment easy because we offer only the finest. You will always be happy owning the best.

TeleVue – Vixen – Coronado

At ATC the best is more affordable than you think. For as little as $85, the TeleVue Plössl is a bargain in a premium quality eyepiece. At that price there is no reason to start with anything else and your appreciation of TeleVue quality will only grow with time. This is the kind of value ATC seeks out for our customers. TeleVue telescopes are in stock. Visit ATC to see and feel what makes these "heirloom" quality instruments.

TeleVue Visionary

Visit Georgia's only stocking TeleVue dealer. Call Gordon and Darlene today for personal advice on the right equipment for you!
www. AbbevilleTelescopeCo.com - gphoto1@alltel.net
351 W. College St - Abbeville, GA 31001 - (229) 467-2878

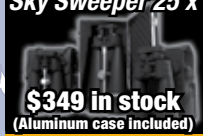
Anttlers Optics

Our Own Best Selling 8"-10"-12" Deep Space Observer Telescopes

- 2 Speed Crayford focuser
- Roller bearing and Teflon
- Many more standard features!

10" DSO $579 w/ Free Shipping!

Sky Sweeper 25 x 100



$349 in stock
(Aluminum case included)

Astronomy Binoculars
- Broadband multi-coated lenses and BAK4 Prisms
- Waterproof

CELESTRON **Celestron Specialist**
Toll Free- 1-866-409-6965
www.anttlersoptics.com

Reader gallery

COMET C/2006 M4 (SWAN) (10-inch Schmidt camera at f/1.5, Sigma 1603 CCD camera, LRGB image with exposures of 260, 60, 60, and 70 minutes, respectively, taken September 30, 2006, at 3h05m UT) /// **MICHAEL JÄGER AND GERALD RHEMANN, VIENNA, AUSTRIA**

INTERPLANETARY WANDERER

A brand-new comet graces the sky

In July 2006, Rob Matson of Irvine, California, and Michael Mattiazzo of Adelaide, South Australia, independently found a comet on images obtained from June 20 to July 5 with the Solar Wind Anisotropy (SWAN) camera aboard the Solar and Heliospheric Observatory (SOHO) spacecraft. Comet C/2006 M4 (SWAN) reached perihelion September 28, 2006. In early October, several Northern Hemisphere observers reported the comet as a naked-eye object with a 0.5°-long tail. These imagers took this picture 2 days after perihelion, when the comet was in the constellation Ursa Major, near the Coma Berenices border.

Send your photos to: *ASTRONOMY* Reader gallery, P. O. Box 1612, Waukesha, WI 53187; e-mail to readergallery@astronomy.com.
Please include your full name, date and location of image, and complete photo data: telescope, camera, film, and exposure information.

C/2006 P1 (McNAUGHT) surprised amateur astronomers with its brightness in the first two weeks of January. The comet shone as a naked-eye object during twilight. (Canon digital SLR, 300mm lens, ISO 100, ½-second exposure, taken January 12, 2007, at 4:45 P.M. local time) /// **MICHAEL JÄGER AND GERALD RHEMANN, VIENNA, AUSTRIA**

COMET McNAUGHT glowed at magnitude 17 when discovered. On January 9, it reached magnitude –2. (3.2-inch Stellarvue SV80S refractor at f/6, Canon EOS 20D digital SLR, 1/40-second exposure, taken January 11, 2007, at 5:01 P.M. EST from Chapin Beach, Dennis, Massachusetts) /// **CHRIS COOK, EAST DENNIS, MASSACHUSETTS**

MELOTTE 15 is a newborn open cluster that formed from emission nebula IC 1805, which lies 7,500 light-years away in Cassiopeia. (20-inch RC Optical Systems Ritchey-Chrétien reflector at f/8.3, Yankee Robotics Trifid II 6303 CCD camera, Astrodon filters Hα/SII/OIII image with exposures of 300, 300, and 280 minutes, respectively) /// **KEN CRAWFORD, RANCHO DEL SOL CAMINO, CALIFORNIA**

THE CAT'S PAW NEBULA (NGC 6334) in Scorpius lies almost 3° east-northeast of magnitude 1.6 Lambda (λ) Sco. This emission nebula measures 40' across. (7.2-inch Astro-Physics EDT apochromatic refractor with focal reducer yielding f/6.7, Canon 20Da digital SLR with Astronomic infrared-blocking filter, stack of ten 10-minute and ten 15-minute images) /// **DON WESTERGREN, LA MESA, CALIFORNIA**

Astronomy (ISSN 0091-6358, USPS 531-350) is published monthly by Kalmbach Publishing Co., 21027 Crossroads Circle, P. O. Box 1612, Waukesha, WI 53187–1612. Periodicals postage paid at Waukesha, WI, and additional offices. POSTMASTER: Send address changes to *Astronomy*, 21027 Crossroads Circle, P. O. Box 1612, Waukesha, WI 53187–1612. Canada Publication Mail Agreement # 40010760.

ORION® OrionTelescopes.com

ACCESSORY SALE!

SALE!

EZ Finder II™ Reflex Sight

REG. $34.95 **SALE $29.95**

SALE!

Sirius™ Plössl Eyepieces

REG. $42.95 **SALE $34.35**

SAVE UP TO 30% ON OVER 75 ITEMS!

SALE!

2" Dielectric Mirror Diagonal

REG. $119.95 **SALE $101.95**

SALE!

Deluxe Stargazer's Filter Set

REG. $114.95 **SALE $91.95**

SALE!

Paragon™ Professional Field Tripods

From REG. $99.95 **SALE From $84.95**

SALE!

Deluxe Accessory Cases

From REG. $26.95 **SALE From $22.90**

SALE!

Shorty™ 2x Barlow Lens, 1.25"

REG. $39.95 **SALE $31.95**

SALE!

V-Block™ Anti-Fringing Filters

From REG. $49.95 **SALE From $39.95**

BARLOWS | CASES | DIAGONALS | FILTERS | FINDER SCOPES

FREE COLOR CATALOG!
Call toll-free
(800) 447-1001
or request it online.

ORION 32 YEARS
TELESCOPES & BINOCULARS

Everything for the Amateur Astronomer — Delivered Direct

IMAGINOVA

Astronomy made simple.

Who says Astronomy has to be complicated? Let a NexStar SE help you find thousands of stars, planets galaxies and more at the touch of a button! The new NexStar SE family combines unprecedented ease of use with advanced features and incredible value. Buyer's remorse not included.

- Series features 4" Maksutov-Cassegrain, 5", 6" and 8" Schmidt-Cassegrain computerized telescopes
- Computerized hand control with nearly 40,000 object database and motorized altazimuth mount
- StarBright® XLT enhanced coatings for maximum light transmission and clarity
- SkyAlign™ allows you to align on any three bright objects, for a fast and easy alignment process
- Flash upgradeable hand control; update your telescope's operating software via the internet
- All Nexstar SE models are GPS compatible and come standard with an auxiliary port for use with additional accessories
- Internal battery compartment to prevent cord wrap during use
- Includes NexRemote™ telescope control software, for advanced control of your telescope via computer
- "THE SKY®" Planetarium software – with 10,000 object database, printable sky maps & enhanced images

NexStar 6SE

NexStar® SE Series

[1] Align your NexStar SE telescope in minutes with our new SkyAlign technology. Just point the telescope at three bright stars and let the computer do the rest. You don't even need to know the names of the stars!

[2] Flash upgradeable hand control contains a database of nearly 40,000 celestial objects and advanced software features including SkyAlign, Identify Mode, User-definable Horizon Limits, and Precise GoTo.

[3] Designed for portability: with largest model weighing only 24 lbs, spend more time observing with these lightweight and easy to set-up telescopes.

[4] Exclusive Features of the 4SE & 5SE: tripod features built-in wedge which allows the them to be used for astrophotography! Includes a camera control feature that allows you to remotely take a series of timed exposures using your digital SLR camera.

NexStar 4SE (4")	$599.00
shipping and handling $40.00	
NexStar 5SE (5")	$799.00
shipping and handling $45.00	
NexStar 6SE (6")	$999.00
shipping and handling $50.00	
NexStar 8SE (8")	$1399.00
shipping and handling $60.00	

Suggested retail in U.S. Dollars. Pricing and shipping charges are suggested for products ordered and shipped in the U.S.A. only.

CELESTRON PREMIER SELECT DEALER

TELESCOPES.COM	888.988.9876	www.telescopes.com
ASTRONOMICS	800.422.7876	www.astronomics.com
OCEANSIDE PHOTO AND TELESCOPE (OPT)	800.483.6287	www.optcorp.com
ADORAMA	800.223.2500	www.adorama.com
B&H PHOTO	800.947.9970	www.bhphotovideo.com
OPTICS PLANET	800.504.5897	www.opticsplanet.com
SCOPE CITY	800.235.3344	www.scopecity.com

CELESTRON®

www.celestron.com/se